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Monterey, California. Naval Postgraduate School

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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**APPLIED WARFIGHTER ERGONOMICS:
A RESEARCH METHOD FOR EVALUATING
MILITARY INDIVIDUAL EQUIPMENT**

by

Koichi Takagi

September 2005

Thesis Advisor:	Nita Lewis Miller
Second Reader:	Nick Dew

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REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE 23 September 2005	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE: Applied Warfighter Ergonomics: A Research Method for Evaluating Military Individual Equipment			5. FUNDING NUMBERS
6. AUTHOR(S) Koichi Takagi			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.	
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	12b. DISTRIBUTION CODE

13. ABSTRACT (maximum 200 words)

The objective of this research effort is to design and implement a laboratory and establish a research method focused on scientific evaluation of human factors considerations for military individual equipment under both laboratory and field conditions. This integrated approach for laboratory and field conditions is the first of its kind for military human factors research, enabling an unparalleled degree of scientific rigor in the collection of empirical human factors data. This effort includes: 1) a state-of-the-art usability laboratory designed specifically for quantitatively evaluating military individual equipment; 2) a rugged, embarkable, fully self-contained, portable usability laboratory for field research in military environments; 3) a codified manual for using the two main configurations (stationary and portable) of the usability laboratory, written for the beginning usability researcher; 4) a set of validated procedures for applying sound human factors principles, and traditional and non-parametric statistics to the specific problem of usability testing of military individual equipment; 5) a proof-of-concept practical application of the laboratory and procedures to a specific problem, namely the usability testing of ruggedized personal digital assistants (RPDAs) designed for United States Special Forces operations.

14. SUBJECT TERMS Devices, Ergonomics, Handheld, Human Factors, Individual Equipment, Noldus, Observer, PDA, Personal Digital Assistant, RPDA, Usability Laboratory, Usability Testing			15. NUMBER OF PAGES 293
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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APPLIED WARFIGHTER ERGONOMICS: A RESEARCH METHOD FOR EVALUATING MILITARY INDIVIDUAL EQUIPMENT

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Submitted in partial fulfillment of the
requirements for the degrees of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

and

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

The objective of this research effort is to design and implement a laboratory and establish a research method focused on scientific evaluation of human factors considerations for military individual equipment under both laboratory and field conditions. This integrated approach for laboratory and field conditions is the first of its kind for military human factors research, enabling an unparalleled degree of scientific rigor in the collection of empirical human factors data. This effort includes: 1) a state-of-the-art usability laboratory designed specifically for quantitatively evaluating military individual equipment; 2) a rugged, embarkable, fully self-contained, portable usability laboratory for field research in military environments; 3) a codified manual for using the two main configurations (stationary and portable) of the usability laboratory, written for the beginning usability researcher; 4) a set of validated procedures for applying sound human factors principles, and traditional and non-parametric statistics to the specific problem of usability testing of military individual equipment; 5) a proof-of-concept practical application of the laboratory and procedures to a specific problem, namely the usability testing of ruggedized personal digital assistants (RPDAs) designed for United States Special Forces operations.

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ACKNOWLEDGMENTS

California, San Diego, was instrumental in the successful conduct of the case study. She assisted in configuring the Observer software, running and troubleshooting the test scenarios, operating video equipment, coding observations, and finally in presenting the results.

SFC Swanson and SSG Gregory Bumann at the 229th MI Bn, and SSgt Boissoneau at the Marine Corps Detachment at the Defense Language Institute, were consummate professionals in arranging for DLI student participation in this research.

My dear wife Melissa and my sons Jonathan and Christopher have been supportive, patient, and encouraging throughout my studies at the Naval Postgraduate School. They are my inspiration and my motivation and I am incomparably fortunate to have them.

EXECUTIVE SUMMARY

End users bear the burden of poor design, and persuading users to learn and use a system's capabilities goes beyond mere functional effectiveness. There is a human factors gap in the Test and Evaluation process, and a need within the Department of Defense (DoD) for a laboratory and a reliable research methodology to perform scientifically rigorous human factors evaluations that goes beyond subjective observations and survey data. Rather than "next-bench" testing between technical experts, true usability testing should involve representative participants under realistic conditions.

The objective of this research effort is to design and implement a laboratory and establish a research method focused on scientific evaluation of human factors considerations for military individual equipment under both laboratory and field conditions. This integrated approach will represent the first of its kind for academic and military human factors research, enabling an unparalleled degree of scientific rigor in the collection of empirical human factors data. This effort includes: 1) a state-of-the-art, well-tested, and professional usability laboratory designed specifically for quantitatively evaluating military individual equipment; 2) a rugged, embarkable, fully self-contained portable usability laboratory for field research in all military environments; 3) a codified manual for using the two main configurations (stationary and portable) of the usability laboratory, written for the beginning usability researcher; 4) a set of validated procedures for applying sound human factors principles, and traditional and non-parametric statistics to the specific problem of usability testing of military individual equipment; 5) a proof-of-concept practical application of the laboratory and procedures to a specific problem, namely the usability testing of ruggedized personal digital assistants (RPDAs) designed for United States Special Forces operations.

In March of 2004, the Special Operations Command (SOCOM) requested a human factors evaluation of the RPDAs they have fielded in Iraq and

Afghanistan. At that time, the DoD did not have a facility equipped specifically to test military individual equipment in the manner needed for comprehensive software and hardware usability testing. Consequently, a behavioral observation laboratory, the Applied Warfighter Ergonomics (AWE) Center, was designed and constructed for this purpose. Since then, the AWE Center has generated serious interest from a number of different DoD and federal agencies. It will also serve as the basis for much future research at NPS. The equipment has been modified at NPS with battery packs so that a researcher can follow a user into the field, recording how users operate the equipment and the context with which it is employed. All the necessary equipment fits into three waterproof transit cases, so that an actual field study could be conducted to validate the results obtained from a controlled laboratory experiment.

Digital videos recorded in the laboratory or in the field are manually coded into data files using the Noldus Observer software. The technical details of the process have been written into a Users Guide, which distills hundreds of pages of documentation and usability references into a focused, stand-alone tutorial. The developer of the software is using our lab as a model on their website.

This thesis details an experimental design, data collection method, analytical procedure, lessons learned and recommendations for future researchers. Both qualitative and quantitative means are employed to provide human factors usability testing.

To validate the laboratory and the procedure, a small case study comparing three different RPDAs was conducted. The case study was a proof-of-concept and was not expected to be conclusive. Soldiers and Marines at the Defense Language Institute were brought to NPS in small groups. Participants were given a pre-operation survey with 45 questions that attempt to capture their technology experience and military background. The participants went through a 30-minute tactical scenario, during which they performed various communications and navigation tasks while equipped with body armor and rifles. The scenario was scripted to drive the participants to perform the tactical tasks

using conventional means (such as with a paper map), in order to provide a baseline measure of their abilities. Later in the scenario, they performed similar tasks using the RPDA. Quantitative measurements such as task time, tactical posture, error rate, and category of errors were recorded while users employed both conventional and RPDA means to perform the tasks. When quantitative results were not conclusive, recommendations were possible based on qualitative observations in the lab and the field.

Inter-rater reliability statistics verified that the behavioral measurements were reliably coded using well-defined criteria. We compare the task times assigned by different researchers on the same video observation file and compute a confusion matrix, index of concordance, and Cohen's κ.

Quantifying individual differences between participants reduces the noise in the measurements, and reduces our required sample size. Testable measures of participant effect, like the baseline tasks, are preferable to surveys, which are prone to a variety of errors. With a properly constructed experiment, we can justify quantitative analysis of human factors data.

Parametric and non-parametric statistics were used to compare devices in the case study. High participant attrition from the study limited the extent to which rigorous statistical analysis could be performed on the data. Some users voiced strong opinions about the devices in their post-operation surveys. This research has shown that perception can influence the adoption of innovations more strongly than quantitative performance.

This thesis fills the human factors gap in the T&E process. There are Special Forces operators and Marines in Iraq and Afghanistan using all of these devices today. Results from this work and from research using this laboratory will be applied by SOCOM to improve current and future RPDAs. This laboratory will make the Naval Postgraduate School the premiere military individual equipment testing site in the country.

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I. INTRODUCTION

A. THESIS ORGANIZATION

This research effort began as a human factors study of military ruggedized personal digital assistants within the Naval Postgraduate School's Tactical Network Topology project for the United States Army Special Operations Command. This thesis is organized into five major parts. After the introductory material, Part II: Design and Implementation describes the technical details of the laboratory designed and constructed to facilitate the study. Part III: Approach describes a general approach specifically for conducting a usability analysis of military individual equipment The case study reported in Part IV serves as a proof-of-concept for the laboratory and the approach, and is a complete study in its own right. The final conclusions and recommendations, Part V, discuss the future of this laboratory, its applicability to other problems, and ways to build on this groundwork to facilitate rapid, effective usability research of other military individual equipment. The appendices contain the data collected during the case study and other relevant resources and can be used as a guide for future data collection efforts.

B. PROBLEM STATEMENT

1. Description

The successful development of an innovation from concept to an established product is closely linked to the user's ability and desire to employ the product. Developers who are too focused on the underlying technical capabilities of their inventions may be surprised that their products are not adopted by their targeted users. Apple Computer Fellow Alan Kay tells us that to users, "the interface *is* the application," and features that are not apparent, do not exist.

Traditional human factors research, including usability analysis, often relies on subjective data, such as surveys and free-form user feedback. These data can be difficult to reproduce and be prone to errors due to user bias and

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distorted recollection. Military equipment places even greater demands on the usability analyst. Military equipment is rarely designed for, or even appropriately evaluated in, a controlled laboratory environment. Both the physical and psychological environments in which military equipment is employed have impacts on the human factors considerations of that equipment.

Military individual equipment is that equipment that is normally carried and employed by a single person in combat. Examples include: personal weapons, body armor and protective gear, load bearing equipment, navigation aids, and portable communications equipment. Individual equipment is relatively inexpensive on a per-item basis. Unlike the research and development programs for larger and more expensive military items, individual equipment items may not be subjected to extensive human factors testing or systems integration with the "whole system" encompassing everything a ground combat Soldier or Marine may typically carry with them into battle. Equipment deficiencies and incompatibilities may not be noted until the equipment is actually fielded.

The main challenges to performing usability analysis on military individual equipment are in apparent diametric opposition:

- *To be scientifically valid*, the evaluation should be repeatable, comparable between systems, and ideally, yield statistically rigorous results.

- *To have predictive and inferential relevance*, the equipment should be tested by representative users under realistic conditions.

The demand for validity might lead us to perform a controlled laboratory study using convenient participants, such as students. The compromises in realism to capture accurate data and achieve statistically supportable results may lead to a test so artificial as to be pointless. Pursuing the goal of relevance, perhaps by conducting a field exercise using real Soldiers and Marines in a tactical scenario, results in a test that is not repeatable, with many variables being uncontrolled, confounded, and even unidentified. Highly subjective after-action reviews with operators are subject to unintentionally distorted recollection

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and individual biases. Such data are also difficult to compare across different training scenarios

Military individual equipment that is usable and appealing to users will increase the rates of adoption and effective employment. This thesis proposes a method for scientifically evaluating the usability and other human factors considerations of modern military individual equipment under both laboratory and field conditions.

2. Background

Various agencies within the Department of Defense are currently developing and fielding a number of handheld computing devices known collectively as Ruggedized Personal Digital Assistants (RPDAs). These devices are similar to, and often based on, the commercial personal digital assistants (PDAs) known as "Palm Pilots", "Pocket PCs", or "Windows CE" devices. Civilian PDAs, introduced by Apple in 1993 and popularized by Palm in 1996, introduced a new paradigm in computing and mobile information accessibility, and new human interface challenges to designers. Military handheld computers have unique human factors considerations. Civilian PDA interfaces are not designed to be used while the operator: 1) simultaneously attends to mental and physical external stimuli such as enemy activity, 2) wears and employs other equipment and weapons which may also require the use of both hands and eyes, or 3) operates under environmental extremes, such as wearing cold-weather gloves.

As with any new technology, there is the challenge of encouraging and facilitating its adoption. The "diffusion of innovation" of electronic devices that supplant existing (manual) systems or provide novel capabilities can be slow when users have little experience with such devices, have low confidence in the electronic device, or have a mission-critical or life-and-death requirement for reliability.

Decades of human factors research have produced guidelines for cockpit design, control panel layouts, and websites, among other interfaces. Currently,

there is not a well-defined methodology to evaluate the human factors issues or adoption strategies pertinent to military RPDAs.

3.   Rationale for Conducting Study

Military RPDAs are at the cutting edge of human-machine interface technology. Human factors considerations are currently being accounted for in an ad-hoc and "gut-instinct" manner, if at all. This study will produce a rigorous method for examining the human factors considerations of military RPDAs. The results of this study will directly influence the ongoing development and fielding procedures of Special Operation Command's current military RPDA. Other organizations will be able to use this research to better design and field military RPDAs now and in the future.

4.   Research Questions

What human factors considerations are generic to handheld devices under normal civilian operating conditions?

What human factors considerations are specific to handheld computing equipment used by military personnel?

How can these human factors issues be tested and evaluated in a laboratory environment, and what are the drawbacks of laboratory testing and evaluation?

How can these human factors issues be tested and evaluated in a field environment, and what are the drawbacks of field testing and evaluation?

What measures of performance and measures of effectiveness should be applied to the human interface of handheld military electronic devices?

What factors do military personnel consider during the adoption of handheld electronic devices? How can a fielding plan address these factors in order to facilitate the successful training and employment of these devices?

What diffusion of innovation considerations should be incorporated into the research and development of military personal electronic devices?

C.   LITERATURE REVIEW

Several fields of research are most pertinent to this study: human-computer interaction, usability testing, and the study of the diffusion of innovations.

1.   The Diffusion of Innovations

Everett Rogers's *Diffusion of Innovations* (2003), in its fifth edition since the original was published in 1962, is widely recognized as the foundation work in the field. His basic approach and specific definitions are cited in virtually all diffusion and adoption literature. Rogers (2003) defines *diffusion*:

> The main elements in the diffusion of new ideas are: (1) an innovation (2) that is communicated through certain channels (3) over time (4) among the members of a social system.

In a number of engaging case studies, he illustrates the ranges and implications of innovations, communication channels, time, and social systems within his framework. Rogers identifies five categories of adopters as having distinct characteristics and motivations with respect to innovation: innovators, early adopters, the early majority, the skeptical late majority, and the traditionalist laggards. He uses these and other specific generalizations to draw parallels between case studies of subjects as diverse as chicken farmers in Africa, doctors in Illinois, and cell phone users in Finland. The first edition of *Diffusion of Innovations* (Rogers, 1962) introduced the classic "S-shaped curve of adoption" (Figure 1). Through a series of extensive and rigorous experiments, Rogers demonstrated that the cumulative percentage of individual adopters of innovations (ideas, new technologies, or social practices) follows a normal probability distribution under a wide variety of circumstances. Rogers then demonstrates that the cumulative distribution of adopters generally follows the same S-shaped curve for *organizations* adopting innovations, as well.

Subsequent studies have established that the top official, head of household, or other nominal leader of the organization is not necessarily the decision maker in the adoption process. Identifying a specific individual responsible for adoption decisions is often complex or even fruitless.

Figure 7-1. The Number of New Adopters Each Year, and the Cumulative Number of Adopters, of Hybrid Seed Corn in Two Iowa Communities
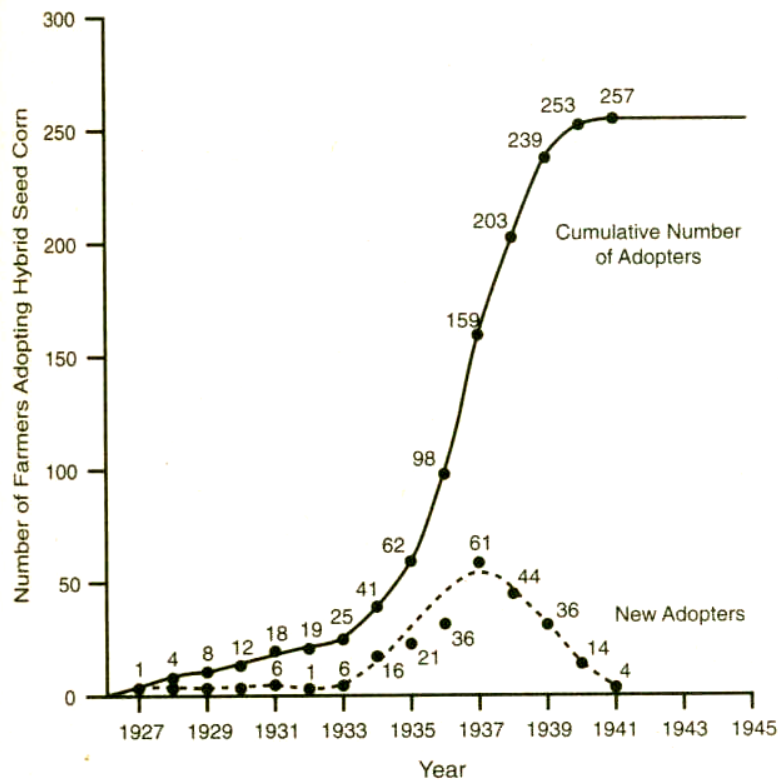
The cumulative number of adopters of hybrid seed corn approaches an S-shaped curve over time, while the frequency distribution of the number of mean adopters per year approaches a normal, bell-shaped curve. Early in the diffusion process, relatively few individuals adopt in each time period. Gradually, however, the rate of adoption speeds up until all (or almost all) members of the system adopt the innovation.

Source: Based on Ryan and Gross (1943).

Figure 1. S-Shaped Curve of Adoption from Rogers, 2003, pp. 273

Denrell and March (2001) offer mathematical models of adoption and use computer simulation to demonstrate how experiential learning in individuals and organizations can produce a "hot stove effect." A cat that sits on a hot stove lid once will never sit one again – but will never sit down on a cold stove lid, either [from a parable by Mark Twain]. Denrell and March (2001) demonstrate that alternatives to the status quo (innovations) often share these characteristics:

- initial performance (among novices) is lower than the expert performance seen after competence develops with the innovation,

- initial performance has higher variation than later performance - systems are more stable at their final potential,

- variability and risk of failure exist among alternatives, and final performance may be substantially less than the status quo.

Denrell and March (2001) demonstrate through simulation that organizations that tend to persist in alternatives to reach a higher level of competence will therefore often persist in evaluating poor alternatives, and thereby fail and be weeded out. Due to high variability, risky alternatives will have runs of poor returns, eliminating individuals and organizations that take on risky alternatives. These effects combine to produce a systematic bias in favor of reliability, manifested as apparently "risk-averse" survivors. The factors that affect the success of alternatives and of individuals who adopt them include:

- learning time required to gain competence,

- variability in initial performance within an alternative (how risky is a particular alternative?),

- variability in potential performance among all alternatives (how much better are the good alternatives?),

- aspirations of desired performance (how much does the decision maker really want or need to improve to survive?).

The factors that influence buyers deciding between products are the same as those that influence adopters of other types of innovations. Much research exists to explore how successful marketers encourage the adoption of their brands by consumers.

In contrast to analyzing what makes adopters switch to alternatives, Carpenter and Nakamoto (1989 and 1994) examined how leading brands come to dominate markets for decades. They propose that pioneering alternatives (first-to-market innovations) have an advantage beyond their initial uniquely desirable attributes. Not only can pioneers modify their product towards user preferences, but they also have the *ability to directly influence market preferences*. Through experiments with actual products and participants, Carpenter and Nakamoto (1989) showed that successful pioneering products could significantly influence user preferences in new markets. It is then much more difficult for later competitors to differentiate themselves from the pioneer. The successful pioneer shifts users' desires and preferences towards the pioneer's greatest strengths.

Carpenter, Nakamoto, & Kent (1990) identified ways that later alternatives can be made more attractive in a market dominated by pioneers. Shankar, Carpenter, and Krishnamurthi (1998) followed up that research with strategies for late movers to reshape a market and arrest the pioneering brand's dominance by identifying a specific, superior position away from the pioneer.

User preferences for alternatives can be manipulated in other ways. Carpenter, Glazer, and Nakamoto (1994) extended Rogers' (2003) principle of *relative advantage* – that one alternative is somehow objectively better than another for the adopter. Carpenter et al. (1994) showed that when alternative products have no meaningful differentiation between them (such as shampoo and instant coffee), consumers preferences can be significantly swayed by the successful marketing of irrelevant attributes that have no impact on objective product performance. Their experiments showed that consumer valuation of alternatives is not properly modeled by a rational choice interpretation. They also showed that there is significant interaction between the cost of the alternative and the perceived value of the irrelevant alternative – that is, a premium price tends to reinforce the value of an irrelevant alternative. As a specific example, Carpenter, Glazer and Nakamoto (1994) offered irrelevant differences in CD

players, pasta types, and down jackets to participants in a controlled experiment. The strength of the effect, that irrelevant attributes were positively valued in premium priced products, surprised the researchers.

2. Human-Computer Interaction

Functional system designs with human interaction must: 1) accept and process user input, and 2) perform some functional task. This is true for all manner of interactive systems (mechanical, electronic, or social). *Context-aware* designs present a different interface to the user(s) depending on the immediate context of use.

A context-aware design (compared to a context-*un*aware interface for the same system) can improve user efficiency while decreasing errors and training requirements. Contextual awareness is becoming increasingly a part of modern user interfaces, information processing, decision-support, and command and control systems for military applications. Selker and Burleson (2000) introduced a framework for discussing computer designs that can be extended to all interactive system models:

- *task models* (Lieberman and Selker, 2000) are the acts that the user directly performs to exercise some functional capability of the system,
- *user models* consist of task-relevant background information about the user,
- *system models* are the capabilities of the [computer] system.

Norman (2002) analyzed a number of mechanical systems in which task models are not well-defined for the user, user models are improper or ignored, and system models are misleading or unavailable to the user.

Rich (1999) argued that, "for many interactive computer systems, the user community is sufficiently heterogeneous that a single model of a canonical user is inadequate." She presents three techniques for building user models:

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- identifying the vocabulary and concepts employed by the user,

- gauging the responses with which the user seems satisfied, and

- using *stereotypes* (a collection of user traits) to generate many facts from a few.

People are most familiar with machine systems that produce direct, computational, and highly accurate results from quantitative input data. "Expert," or knowledge-based, systems produce indirect conclusions (often, qualitative, and in a restricted field) that closely parallels the conclusions drawn by a human "expert" in that field. Experts (human or machine) are believed to perform better than "novices" (non-experts) in part because they use superior internal models of the system (Jonassen, 2003).

In case studies, Rich (1999) followed the development of an expert system that uses "stereotypes" to individualize a user model. Cognitive research has shown that a problem's representation to the user has a tremendous effect on a subject's internal model of the problem (Jonassen, 2003; Norman, 1993). Naturalistic decision making (NDM) theory asserts that, "often the biggest problem facing decision makers is that they do not know which questions to ask" (Meso, Troutt, & Rudnicka, 2002).

Context-aware design can help bring novices up to expert-level performance by properly presenting the contextually relevant data. A user can then construct an internal model that accurately reflects the situation (in other language, build "situational awareness"). A context-aware design might then suggest (or conversely, suppress) possible courses of action, rather than overwhelm the user (often termed, "information overload").

System models can adopt a "process-centered" or a "product-centered" view of the system components (Abecker, Bernardi, Hinkelmann, Kuhn, & Sintek, 2000). A context-aware design should be able to gather data on context not explicitly given to it, such as: time, place, weather, user preferences, skills, knowledge, and experience, and the history of interaction. These definitions of context can also be extrapolated to states unfamiliar to the system: not just,

"what is likely in the neighborhood right now," but, more generally, "*what is typically in a neighborhood like this*" [emphasis added] (Lieberman & Selker, 2000).

Developing context-aware designs. Context-aware designs, by definition, respond to external conditions. They have a degree of sophistication that is unusual for machines. Harter, Hopper, Steggles, Ward, and Webster (2002) go so far as to describe a particular context-aware platform as "sentient". Colloquially, the term "smart" is often variously used to refer to a system that:

- performs complex tasks with high "ease of use", *or*
- uses a knowledge base to produce conclusions not obvious to a non-expert, *or*
- attempts to predict or infer user action (that is, at least rudimentarily context-aware).

The first definition merely indicates the initial employment of any technological system. This level of human factors engineering is well appreciated by industry (Vredenburg, 1999 and 2003), but has nothing to do with contextual awareness. A marvel of complexity may produce incorrect output, but be (erroneously) believed because it bears a false "pedigree criteria" for credibility (Vedder, 2004).

Knowledge-based systems, built on an complex system model, must also assess the context of the data presented to the system, and the user's state to produce useful and reliable results. Suchman (1987, ch. 6-7) described in great detail a case study of an expert system that has an excellent knowledge base and internal system model, but does not adequately collect information on the user's context. Because it is context-unaware, its comprehensive knowledge base is unavailable to the user, and the system is a failure.

Perception can create reality. Persuading users to learn and use a system's capabilities goes beyond mere functional effectiveness. Design and aesthetics can affect a user's perception, belief system, and even task ability (Csikszentmihalyi, 1990). Picard's continuing research (2004) in "affective

computing" has shown that a critical part of our ability to see and perceive is not logical, but emotional. Her Affective Computing Research Group at the MIT Media Laboratory is studying the nature of human emotions, how to sense and model them (essential parts of a complete user model), and experimenting with "synthesizing emotions" in machines to create affective interfaces and applications (Picard, 2004). "Seductive" experiences create an emotional bond with their audience (Khaslavsky & Shedroff, 1999). A seductive interface enhances the value to users, and has the goal of persuading users towards some aim. Khaslavsky and Shedroff described three basic steps towards seduction: enticement, relationship, fulfillment. Technologies now exist that are actively persuasive in their own right, such as interactive agents that steer users towards a company's product (Berdichevsky & Neunschwander, 1999).
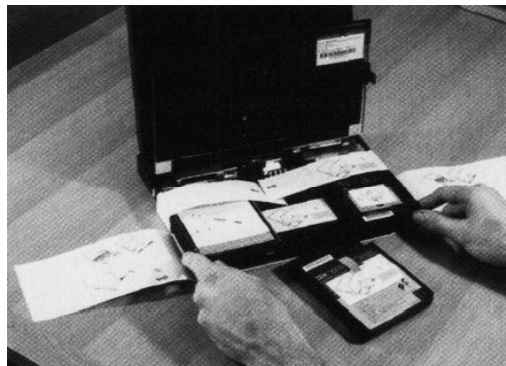
Figure 2. The IBM "Out-Of-Box Experience" – a physically context-aware design (Selker & Burleson, 2000)

Selker and Burleson (2000) described physical, mechanical and electronic context-aware designs. For example, the setup instructions for an IBM™ laptop computer are not presented as a (context-unaware) traditional manual (Figure 2) The instructions are on strips of paper, in and on various parts of the computer, so that the user is presented with new actions *only when they are useful* (one strip is on the outside, another becomes visible when the machine lid is raised, etc.) Norman (2002) called these context-based constraints "forcing functions" –

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situations in which actions are constrained (the system correctly interprets the user's context) so that failure at one stage prevents the next step from happening. Norman (2002) also identifies a number of other physical and mechanical designs that notably assist or confound the user by their degree of contextual awareness. Forcing functions can be misapplied, and thereby prevent an appropriate means of recovery. This will lead to users quickly discovering ways to circumvent the system and fool the system's user model, and in doing so, destroy the system's context (Suchman, 1987, ch. 7). If users absorb such actions into their task model for the system, both performance, and confidence in the system, will suffer.

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 ┌───────┐       ┌───────────┐       ┌────────┐
 │ Input │ ────▶ │  Process  │ ────▶ │ Output │
 └───────┘       └───────────┘       └────────┘
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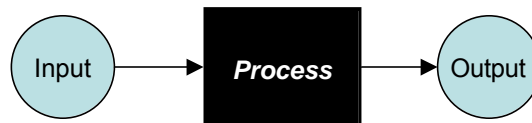
Figure 3.   The Traditional Engineering and Science "Black-Box"
system model

Harter et al. (2002) describe, in great detail, the technical issues concerning a specific hardware and software platform that gains contextual awareness (and maintains an accurate user model) by sensing the user's location in a building. Abecker et al. (2000) describe the task models dealt with by their KnowMore project. The KnowMore project deals with the problem of "information overload". A vast amount of knowledge is available through information retrieval tools (search engines), but by contextually modeling user's information needs, the system eliminates unrelated documents and presents the user only with applicable knowledge and compulsory rules. Lieberman & Selker (2000) point out that there is a trade-off between the desire for abstraction and the desire for context sensitivity

Difficulties in Designing Context-Aware Systems. Context-based designs break out of the traditional engineering and science "black-box" model of

system design shown in Figure 3. Lieberman and Selker (2000) propose an expanded, context-aware, systems design model, which is further modified in Figure 4. The traditional component-wise black-box decomposition is useful because it abstracts a particular system function from the (much more complex) whole. Black boxes are often simpler to design, test, and implement. It is exactly this abstraction that reduces context sensitivity.
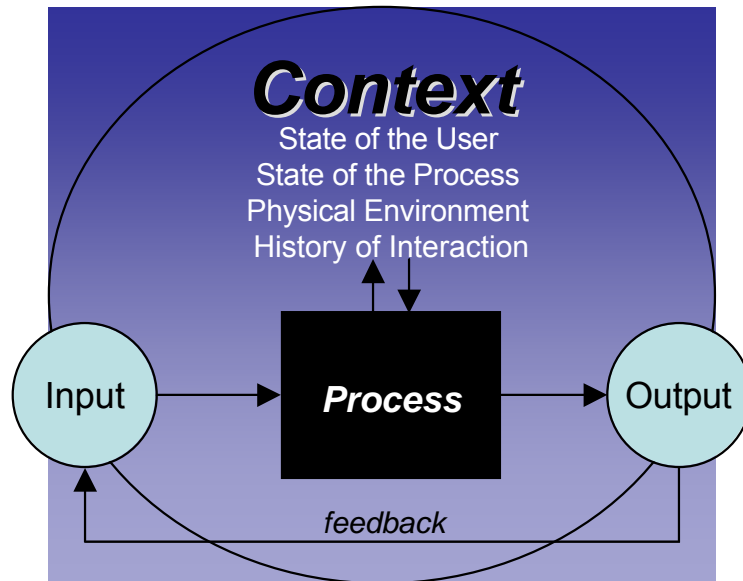
Figure 4.   Context is everything *but* the explicit input and output
(adapted from Lieberman & Selker, 2000)

Vedder (2004) discussed the issues of humans assessing information reliability (specifically, information on the internet), and in what ways humans fail to recognize reliability or unreliability. Highly *accessible* information, such as results from an internet search engine, is often mistakenly held to be *reliable*. The fact that information comes from the internet can give it a misleading "pedigree of reliability" (Vedder, 2004). Vedder (2004) cited no research in this area, but his conceptual discussion can be extended to a measuring instrument that displays more significant digits than are actually accurate, or the display of a so-called "smart" interface. Humans are often at the extremes in their skepticism of machine-displayed information – either too credulous, or too dubious. Good

designs should incorporate a measure of reliability of their output, so as not to lead the user into a false context (of accurate data). Information density and user comprehension can be vastly improved with an appropriate choice of display. Tufte (2001) illustrated a wide variety of ways (good and bad) to display quantitative, multi-variate data.

Berdichevsky and Neunschwander (1999) set out ethical principles of persuasive design, with a "golden rule" that, "actively persuasive technology should never seek to persuade anyone of something they themselves would not consent to be persuaded to." People are persuaded (by other people) based in part on "liking" and "authority" (Cialdini, 1993). Within appropriate contexts, machine interfaces can similarly be made seductive, affective, and authoritative, enabling them to persuade users towards (or against) certain actions.

Displays that do not take operator context into account may be ignored or rejected as inaccurate. Besnard, Greathead, and Baxter (2004) described how flawed mental models (particularly, in a detailed study of the British Airlines 737 crash in 1989 in Kegworth, U.K.) can be mistakenly reinforced by coincidental system responses.

"People's actions are intimately intertwined with artifacts of their work; their team member's roles, responsibilities, and actions; and even their cultural and historical setting," (Olson & Olson, 2003, p. 495). Olson and Olson (2003) charted out how the field of Human-Computer Interaction is transitioning from early research in individual cognitive processes and motor skills, to a knowledge-based understanding of the role of context and "domain expertise" in user interfaces.

The costs of poor design. Hackos and Redish (1998) point out a number of costs incurred by products that are designed without integrated user and task analysis. Cutting corners in the design process can result in lifetime expenditures in:

- lost productivity,

- increased training and re-training time,
- maintenance costs,
- user support costs,
- field maintenance costs,
- correcting mistakes,
- health and safety problems due to improper use,
- administrative and legal costs due to improper use,
- employee frustration leading to low productivity and contributing to attrition,
- and lost sales or poor adoption.

User interface design conclusions. Context-aware designs seek to improve user efficiency while decreasing errors and training requirements. Contextual awareness and presentation are usually, but not always, more complicated to incorporate into designs. Basic human factors considerations dictate that design should follow the human's point of view, rather than the convenience of technical design. Beyond that level, designing contextual awareness requires considering the system from the human's *current* point of view. A good context-aware interface must provide access to all relevant system capabilities, while aiding the user in making appropriate choices and/or restricting the user's ability to make inappropriate choices. Poor attempts at context-aware interfaces may inadvertently restrict access to important capabilities, be jarringly inconsistent, or misinterpret the user's actual context.

The prevailing literature addresses the advantages of incorporating contextual awareness into user interfaces and whole-system designs. Actual examples of context-aware designs are primarily experimental, or in specific and novel applications. There exists little in the way of comparative studies of improvements gained by applying context-aware designs to existing, context-unaware interfaces.

Military information systems are often used in one or more of the following situations:

- Decision makers must make sense of overwhelming amounts of relevant and timely data.

- An operator or watch officer must have a formal "turnover" period to bring his or her relief abreast of the current situation (that is, establish their context of operations).

- A user has considerable freedom to decide how to accomplish a specific task, and different users are more effective operating in their own, personalized "mode."

- Users have greatly varying degrees of skill and training, but all must operate the same system at a minimum proficiency.

- A human, in the position of the system, would have implicit knowledge of many environmental factors (time, weather, historical context) that would not be explicitly entered into a system.

These situations all are candidates for improvement through context-aware system design, and context-aware interfaces. Context-aware design applied to military individual equipment could be implemented in the following areas.

Sensible default behavior. The most likely choice is presented to the user. For example, novices need not enter complicated networking configuration information if the system can determine some configuration that would work. Advanced users might optimize their settings in some other manner.

Restricted options. For users of various categories, based on skill level, tactical role, or security requirements.

Robustness to inputs. Users of tactical equipment will exit applications and turn off the device at any possible time. Components may be disconnected at any time during operation, and power sources may be intermittent. Devices should be robust to all such conditions without corrupting or deleting data or physical damage to equipment.

Informative error conditions and graceful recovery. Error messages should recommend an appropriate recovery procedure (for example, a sensible

default behavior). A universal reset procedure should be available to restore a system to normal operation.

Users should be drawn from typical current users ranging from trainees to highly experienced experts. The demographics and psychographics of the representative group should be compared with those of the larger population of actual users, and significant departures be noted. Pre-interviews with the subjects should identify the following:

- preconceptions and biases about the system,
- their existing understanding of the user, task, and system models, and
- previous experience with similar systems.

An aspect of contextual awareness that is not well discussed in the literature is the trade-off between better performance, using contextual awareness and the benefits of standardization across users. This has particular significance for users of military designs. For a number of reasons in training and wartime, personnel changes often happen rapidly in military units. Replacement personnel may have a wide range of skills and experiences. All military systems must be designed in such a way that users can be substituted for one another without warning, which has implications for how far context aware designs can customize themselves to a specific user model.

A primary purpose of this research is not to develop the "how" of system design, but the "why" – why, and by how much, is a high technology solution better than a traditional system? In what areas does high technology strongly benefit the overall system, and in what areas are diminishing returns seen from applying high technology solutions? The answers to these questions will stimulate further research with at least two goals: 1) to improve specific existing systems, and 2) to encourage system designers to incorporate usability analysis in future system designs from their inception. As with other human factors improvements, it is far easier to create a system with the proper perspective in mind from the beginning, than to retrofit poor designs later.

3. Usability Testing

In the standards document ISO 9241-11, the International Standards Organization (ISO) defines usability and three related terms:

Usability: The effectiveness, efficiency, and satisfaction with which specified users can achieve specified goals in particular environments.

Effectiveness: the extent to which a goal, or task, is achieved.

Efficiency: the amount of effort required to accomplish the goal.

Satisfaction: the level of comfort that the user feels when using a product and how acceptable the product is to users as a vehicle for achieving their goals.

In his brief and very readable *An Introduction to Usability* (1998), Jordan identified and discusses the user characteristics that have the most direct effects on usability: experience, domain knowledge, and cultural background. Jordan (1998) also included disability, age and gender in his list, but within the narrower context of military usability studies, these characteristics are less likely to be relevant.

There are various taxonomies of errors (see Wiegmann & Shappell, 2003, Reason, 1990, Dekker, 2002, and Norman, 2002). The errors commonly measured in usability testing include slips and mistakes. A **slip** occurs when the user knows how to perform a task, but unintentionally does something wrong during the task. A **mistake** occurs when the user has an erroneous model of how the product works (Reason, 1990). Slips and mistakes may indicate different reasons for the commission of an error, but may be difficult to distinguish in some contexts.

As illustrated in Figure 5, Jordan (1998) defines five components of usability in a manner pertinent to the analysis of military systems (boldface and italics added):

Guessability. The effectiveness, efficiency, and satisfaction with which specified users can complete specified tasks with a particular product *for the first time.*

Learnability. The effectiveness, efficiency, and satisfaction with which specified users can achieve a competent level of performance on specified tasks with a product, *having already completed those tasks once previously.*

Experienced User Performance (EUP). The effectiveness, efficiency, and satisfaction with which specified *experienced users* can achieve specified tasks with a particular product.

System Potential. The *optimum level* of effectiveness, efficiency, and satisfaction with which it would be *possible* to complete specified tasks with a product.

Re-usability. The effectiveness, efficiency, and satisfaction with which specified users can complete specified tasks with a particular product *after a comparatively long period away from those tasks.*
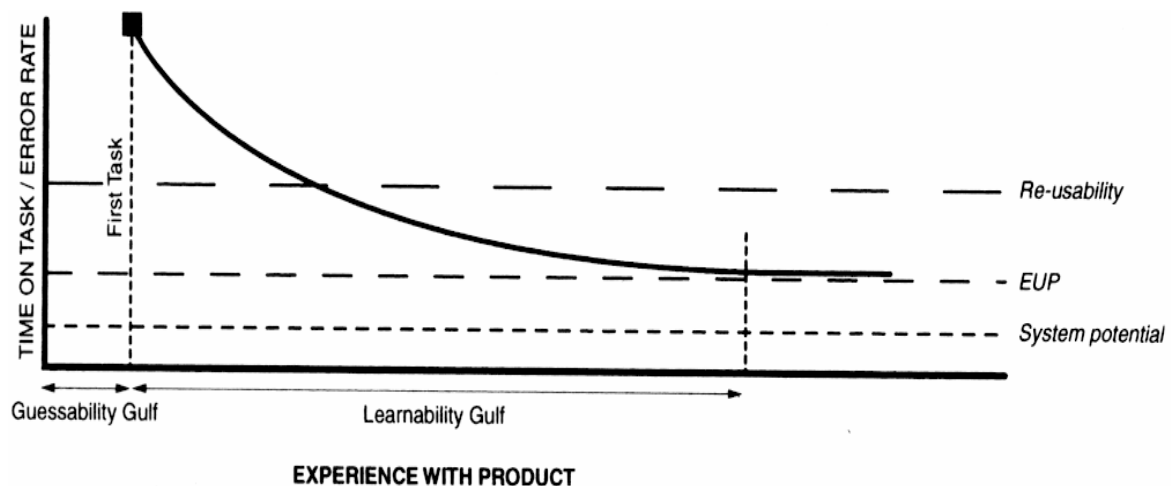
Figure 5.   The components of usability, and an idealized
learning curve (Jordan, 1998).

Why not simply ask users or subject matter experts (SMEs) what they want? Hackos and Redish (1998) point out that users themselves do not know

how to articulate what they do, especially if they are very familiar with the tasks the perform. Users will tend to emphasize difficult, boring, or exciting tasks.

D.   OBJECTIVES

The objective of this research effort is to design and establish a laboratory and research method specifically focused on scientifically evaluating the human factors considerations of military individual equipment under both laboratory and field conditions. This laboratory will represent the first of its kind for academic and military human factors research. The specific results of this effort include:

- a complete, well-tested, and professional usability laboratory designed specifically for evaluating military individual equipment,

- a rugged, embarkable, fully self-contained portable usability laboratory for field research,

- a codified manual for using the two main configurations (stationary and portable) of the usability laboratory, written for the beginning usability researcher,

- a tested set of procedures for applying sound human factors principles to the specific problem of usability testing of military individual equipment,

- a proof-of-concept practical application of the laboratory and procedures to a specific problem, namely the usability testing of RPDAs designed for ground combat personnel.

E.   SCOPE, LIMITATIONS, AND ASSUMPTIONS

This research effort was limited primarily by time and the availability of appropriate participants. In order to both design and fully exercise the capabilities of the laboratory, this thesis was intended to be limited as follows.

Review the extant literature pertinent to the human factors of RPDAs. Identify military RPDAs currently under development.

Discover the requirements for, design, construct, and create training for a usability laboratory suitable for testing and evaluating handheld electronic devices.

Define a methodology for evaluating the human factors considerations of military PDAs, including the software and hardware of behavioral observation systems, data collection procedures, and training.

II. DESIGN AND IMPLEMENTATION OF
THE OBSERVATION LABORATORY

A. BACKGROUND

The bulk of the time in this effort was spent in designing, constructing, learning about, and experimenting with the equipment used for the Applied Warfighter Ergonomics (AWE) Observation Laboratory. The technical details of the installation and use of the lab are given in step-by-step detail in the Applied Warfighter Ergonomics Observation Laboratory Basic User Guide (Appendix B, also published as a stand-alone document).

During the pilot experiments leading up to the case study and during the case study itself, students were brought in to use the equipment in the AWE Observation Lab[1]. These students exercised the various capabilities of the lab, including capturing and editing video, creating DVDs, creating configurations in The Observer software, and coding behavior in The Observer software. They referred only to the Basic User Guide created during this project (found in Appendix B), with occasional coaching where necessary. Feedback during this process refined the Basic User Guide to the point where the last users required no coaching beyond the tutorial in the Basic User Guide to fully perform a basic usability study.

The Naval Postgraduate School Applied Warfighter Ergonomics Observation Laboratory (NPS AWE Observation Lab) was designed to be the first observation laboratory designed explicitly to investigate military individual equipment. Traditional observation laboratories exist in the civilian community that are used variously to study computer interfaces, websites, and small physical devices (Noldus, 2005). There already exist many (often conflicting) human interface guidelines for software, as well as detailed ergonomic studies of

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[1] Students who used the AWE Observation Laboratory during its initial testing included: NPS Human Systems Integration students Petra Alfred, Tim McKnelly, Derek Read, and Matt Simpson, and UCSD undergraduate cognitive science student Katie Buettner.

highly sophisticated, expensive military equipment such as aircraft cockpits and nuclear submarine control stations. Currently, no usability lab exists which is dedicated to the study of the equipment carried by a single soldier or Marine, and the behavior and characteristics of that ground combat Warfighter.

The AWE Observation Laboratory was conceived with this mission statement:

> *To design and establish a laboratory and a methodology for scientifically evaluating the human factors considerations of combat equipment used by military personnel under both laboratory controlled and realistic field conditions.*

The state of the art in behavioral observation hardware and software was sought, in conjunction with the appropriate military equipment to focus the lab on military individual equipment. The following is a general list of the functions that were required to establish this laboratory as uniquely serving the ground combatant:

- robotic digital cameras to record behavior from multiple angles,

- video mixing and editing hardware and software,

- standard issue military individual equipment, such as helmets, body armor, packs, and training rifles,

- large screen plasma display for presenting tactical scenarios to participants,

- wired and wireless network access to the Naval Postgraduate School research network,

- GPS rebroadcasting equipment allowing the reception of real GPS signal inside the laboratory (where GPS signals are usually unavailable),

- wired and wireless network access to the NPS "Gigalab" Tactical Network Topology experimental research network so that the latest networked computing devices developed at NPS could operate within the lab.

Establishing these capabilities required close coordination with the following individuals and agencies.

- Dr. Dave Netzer's Tactical Network Topology (TNT) research program, including a number of students involved in the quarterly TNT experiments,

- Dr. Alex Bordetsky's Gigalab research group,

- Captain Francisco Caceres, student in the NPS Information Technology Management curriculum, for his work with RPDAs,

- the Marine Corps Tactical Systems Support Activity in San Diego, California,

- Noldus Information Technology of Leesburg, Virginia, developer of The Observer software and related observation hardware,

- NPS Public Works department for the installation of a two-way mirror, a GPS antenna on the roof of Glasgow, telephone systems, and other small construction projects,

- NPS Information and Technology Assistance Center (ITACS) for the assignment of static IP addresses to various equipment and network connectivity to the NPS domain for the computer systems,

- Army and Marine Corps staff at the Defense Language Institute (DLI) at the Presidio of Monterey (POM), for access to DLI students as experimental participants.

Detailed point of contact information for the individuals and agencies listed above can be found in Appendix D.

B. TECHNICAL SPECIFICATIONS

A detailed list of all the equipment, by manufacturer and model number, and complete wiring diagrams can be found in the Applied Warfighter Ergonomics Observation Laboratory Basic User Guide (Appendix B). The user guide also contains a complete step-by-step tutorial that would take an inexperienced user through the laboratory hardware and software. An accompanying DVD shows the equipment and procedures for using the laboratory.

C. INSTALLATION

Initial installation of the Observer computer system was performed in a single day by Koichi Takagi of NPS, and Bart von Roekel and John McGraw of

Noldus Information Technology. In addition to the observation equipment purchased from Noldus, the basic requirements for the observation lab included:

- two adjacent rooms (the "participant" and "observer" room) measuring at least 10' x 10'. A much larger room is preferred for the participant room. Each room should be able to be fully isolated from other areas, and have comfortable lighting and temperature controls. Each room must have both electrical and computer network outlets. The observer room may require as many as twenty surge-protected electrical outlets for the observation equipment and supporting various equipment for testing (battery chargers, radios, etc.)

- access between the rooms (for example, through a suspended ceiling) for a considerable amount of cabling,

- wall-mounted remote cameras and their associated cabling,

- installation of a piece of two-way mirrored glass between the rooms. This step required extensive coordination with local facilities maintenance. The glass was installed with the lower edge approximately 36 inches above the floor, so that a seated observer would have full view of the participant over his or her desk. The observer room must be darkened to fully prevent the participant from seeing the observer through the glass. Blinds were installed in front of the two-way mirror, and shelves installed near the cameras, to reduce the participant's self-consciousness and awareness of the observer.

The observation equipment requires ample shelf and desk space for computers, multiple video monitors, the camera controller and video mixer, note-taking materials, and other equipment. Additional adjustments and improvements to the laboratory space required approximately forty additional hours spread over many months.

III. APPROACH FOR USABILITY TESTING

A. OVERVIEW

This thesis is intended to dramatically reduce the demands of performing effective usability research on military individual equipment by providing: 1) equipment customized to the task, 2) a validated, step-by-step procedure for performing all phases of the research from data collection to analysis, and 3) a template (the case study in part IV) for presenting such a study.

Table 1 lists the steps in performing a usability analysis of military individual equipment using the Applied Warfighter Ergonomics Center Observation Laboratory. The rest of this section will describe each step in further detail.

Table 1. Steps in Performing a Usability Analysis
1. Concept
2. Definition of need
3. Design of lab study
4. User identification
5. Focus groups/interviews
6. Pre-surveys
7. Lab testing – obtain quantitative performance metrics
8. Post-operation survey (operation in lab) – qualitative user impressions
9. Analysis
10. Design of field study
11. Field testing – validation of laboratory results through quantitative metrics
12. Post-operation survey (operation in the field) – qualitative user impressions
13. Report

B.   SELECTING PARTICIPANTS

Participants in any usability study should represent a sample of the intended user population. An irrelevant test population is a threat to external validity, to generalizability, and to credibility with the military consumers of the final report. Assumptions about true user populations and test user populations should be determined, clearly stated, and tested where possible to maintain the validity of the study.

A qualitative profile of the typical user population can be developed through focus groups, and interviews with users, subject matter experts, and their leadership, and surveys. Test scores and quantitative ergonomic data, such as physical measurements and capabilities, can also be used to define a working "stereotype" of the user population (Rich, 1999).

C.   CONDUCTING INTERVIEWS AND FOCUS GROUPS

Interviews and focus groups are a method used to gain insight into issues concerning newly designed equipment. Participants may include: sponsors, users, developers and subject matter experts. The interviews and focus group discussions are used to determine things such as: user needs, assumptions and biases, past experiences of the stakeholders, and the conditions under which the devices may used. Focus groups, interviews, and casual conversations with the stakeholders may reveal issues that would not surface elsewhere. Cozby (2004) notes that the group interaction in a focus group can stimulate a variety of responses that might not surface in surveys, interviews, or testing.

D.   ADMINISTERING SURVEYS

Bordens and Abbott (2002) and Cozby (2004) describe many of the issues around conducting effective survey research. In the surveys designed for this research, both open- and closed-ended questions were used to get as much information as possible from concise (3-5 page) forms. The limited availability of relevant test participants makes it important that the survey questions be clear and unambiguous, and not be overly time-consuming. As suggested by Bordens

and Abbott (2002), demographic items are not presented first on the questionnaire, and related items are presented together. For consistency and ease of scoring, a five-point Likert scale ("very dissatisfied" to "very satisfied") is often used to gauge qualitative responses.

In most situations, criteria for grouping the individuals may not be apparent until after the survey data is collected, and the researcher must take care not to prematurely group responses into categories. A question such as, "How many hours per week do you play video games," is better answered with a continuous response (e.g., "enter number of hours") than with pre-assigned categories (e.g., "0-1 hours, 1-3 hours, more than 3 hours") to avoid ceiling and floor effects. After the data are collected, the responses can be grouped into low, medium, and high levels, if desired. Note that some types of statistical analysis are more appropriate with continuous values (the actual response in hours) than with categorical (low, medium, high). However, there may be reason to suspect that such survey data, based on estimates and individual recollection, is not really providing the numerical accuracy implied in the response. In that case, grouping responses into categorical levels may be more accurate.

Table 2.   Checklist for successful survey administration
1. Initial concept of survey – goals, participants, timeframe
2. Institutional Review Board (IRB) approval)
3. Review survey internally (peers and faculty)
4. Administer pilot survey – edit and refine survey
5. Administer actual survey
6. Provide plenty of copies of all paperwork
7. Provide pencils or pens, and clipboards or a writing surface if necessary
8. Introduction and instruction letters to participants
9. Allow adequate time to complete survey
10. Prepare folders and portable storage (filing box, etc.) for copies of blank forms and surveys, and for completed forms and surveys *(see the example in Table 8).*

1.　Pre-operation Surveys

Users should complete a survey before using the equipment to assess their demographic background, relevant experience and skills, and potential biases. The survey responses can be aggregated with the goal of identifying similar groups of users, such as technical novices and experts, or early adopters and hold-out traditionalists. Analysis of the responses may also uncover specific independent variables (IVs) that are indicators or influences on final performance.

2.　Post-operation Surveys

Users should complete a survey after using the equipment to obtain qualitative feedback from the user on the equipment. The results of this survey can be used in conjunction with the usability testing to determine how well users' impressions of their performance and satisfaction with the equipment corresponds to their measured performance. As with the pre-operation survey, the responses can be used to identify categories of users, by their self-reported success and satisfaction measures. Of special interest would be areas where

users self-reports (e.g., survey or verbal feedback) disagreed with their measured performance. For example, a user expressing a high level of dissatisfaction with a device might exhibit a higher level of performance on that device than on a device with which she was more satisfied.

E. CONDUCTING A FUNCTIONAL TASK ANALYSIS AND COGNITIVE TASK ANALYSIS

Tasks performed during testing should be as closely related as possible to the real-world tasks of the user. These tasks can come from a formal operational requirements document (ORD), from less formal statements gathered from focus groups and interviews, or empirically, from a task analysis conducted as a part of the research effort. A functional task analysis may also be used to validate and refine in detail the tasks defined in the ORD or from other sources.

The functional task analysis of how the equipment tested is actually used will identify the tasks that are most relevant to the equipment's operation, and the tasks that are practical to test quantitatively. The task analysis may also clarify the allocation of functions within a larger context. Some tasks are best performed by a human, some are better performed on a device,: these divisions may be situationally dependent.

Hackos and Redish (1998) and Kirwan and Ainsworth (1992) detail many of the various techniques for conducting task analyses, including verbal protocols, observations, and task decomposition. Rubin (1994) and Cozby (22004) present concise and effective recommendations for conducting surveys, usability testing, and experimental design. Their texts were used extensively in all phases of this research.

F. CONDUCTING AN OBSERVATIONAL USABILITY ANALYSIS

The process of turning human behavior and observed events into a quantitative data set is called *coding* or *scoring*. Coding can involve numerical data such as recording times and counting behaviors. Behavior can also be coded in categorical terms, such as types of behaviors, or be more subjective,

such as gauging emotions or intent. The goal of such an analysis is a written record that accurately characterizes the experimental session.

A usability test should define *tasks* to be evaluated, the precise *conditions* under which they will be performed, and specific *standards* that quantify success or otherwise measure performance. Usability data can be collected in the laboratory or in the field. Table 3 lists the important characteristics of laboratory and field research in the context of usability research.

Table 3.   Characteristics of Laboratory and Field Research

Laboratory research	Field research
Controlled conditions	Uncontrolled conditions
Repeatable scenarios	Unrepeatable scenarios
Artificial	Realistic
Can collect a large amount of highly detailed data	Reveals data not seen in lab
	Expensive in time and other resources
	More errors in data collection
	Many confounds
Allows statistically rigorous conclusions	*Validation of laboratory results*

1.   Tasks

Tasks to be evaluated are legitimate when they are defined in a supportable manner and validated through an independent functional task analysis. To the greatest degree possible, tasks should reflect real-world employment of the equipment tested within the artificial conditions of a laboratory, safety and practical restrictions in a field exercise, and the limits of direct measurability. When performing a comparative analysis, tasks should be limited to those that can be performed similarly in each testing condition, whether those be different devices or different groups of users.

Within the Observer software, each task is defined as a separate behavioral class containing two state behaviors: ON task and OFF task. When defined as state behaviors, the software records the period that the task is

performed as a time interval (rather than just as two discrete points in time), which is useful for later analysis.

2. Conditions

Precisely defined, rigorously controlled experimental conditions ensure that the research has sufficient control to maintain internal validity, that the experiments can be replicated, and the data can be appropriately analyzed. Controlling situations involving human behavior can be more complicated that it seems, even within the structure of a laboratory experiment. Conditions should be recorded to the level of detail that they can be replicated by future researchers with no further details provided. At a minimum, researchers must write a detailed, scripted scenario, that includes:

- a timeline,
- a description of what each researcher and participant will be doing at each point in the scenario,
- detailed notes on test equipment settings,
- detailed notes on environmental conditions, such as lighting, and time of day,
- indications of what will trigger each event or behavior of interest, that is, how does the participant know to start a task?
- what equipment will be worn or used, such as helmet, rifle, or handheld device.

The conditions under which the experiment is performed should be recorded as independent variables (IVs) for the session and possibly used in later analysis.

3. Standards: Measures of Effectiveness and Measures of Performance

Tasks and behaviors within a usability test should be evaluated using unambiguous, precisely defined standards coded by independent researchers. Common usability measures are: speed and accuracy (task time), and accuracy (# of errors by type). Other human factors metrics, which are more difficult to

measure, include: initial training time required, skill retention over time, and a device's physical accessibility or ergonomics.

Measures of effectiveness (MOEs), measures of performance (MOPs), and data requirements have precise definitions within military Test and Evaluation (Hoivik, 2005):

> **MOE.** A measure which expresses the extent to which a combat system accomplishes or supports a mission or task. MOEs are designed to address an issue, and should be relevant, complete, precisely defined, and quantifiably measured. MOEs should be directly traceable to a requirements document.

> **MOP.** A quantitative or qualitative measure of a system's capabilities or specific performance function. MOPs are often expressed as distances, times, rates, or ratios

> **Data Requirement.** A number or other measurement which can be collected at a single location, does not depend upon recall or judgment by the data collector, and can be derived directly from the MOPs.

4. Overview of a Usability Test in the NPS AWE Observation Laboratory

To use the AWE Center Observation Lab effectively, researchers should prepare the following:

a. a well-formed research question to investigate. This question may emerge from a formal requirements document, or from a focus group or brainstorming session,

b. a set of the proposed independent variables (IVs) that will be controlled in each observation session. This list may include information about the participant (name, rank, gender, etc.) and information about the scenario or environment ("wearing equipment load A", "night conditions", etc.),

c. a list of tasks to be given to the participant (e.g., "send a message"),

d. a detailed list of "behaviors" (or "events") that will be observed and recorded. Virtually all possible behaviors of interest should be defined beforehand ("start task", "press button 1","user commits error"..., "complete task"). While not all events will occur in each scenario, some events may occur multiple times.

e. a detailed, scripted scenario, as previously described,

f. any required paperwork such as IRBs, consent forms, background questionnaires, etc.

Researchers will produce video files of the observation session for each participant, and use Noldus Observer to score the behaviors observed. The data can be exported in standard formats (such as Microsoft Excel or comma-separated values), and analyzed with Noldus Observer's built in statistics package or external statistics programs of choice.

Multiple coders or researchers can score the same sessions from video files, and then conduct a reliability analysis between the coders (inter-coder reliability). The same coder can be compared against previous observations to measure intra-coder reliability.

The main phases of using the observation laboratory are to set up the experiment, record the session to video, score the behaviors observed during the session, and analyze the data. Table 4 provides a checklist for successfully performing such an observation session.

Practice runs before actually attempting to collect data should be considered absolutely necessary.

Conducting experiments with real human participants and erratic equipment may introduce last-minute changes to the experimental design. When at all possible, contingencies (such as malfunctioning equipment and missing participants) should be planned for in advance, rather than reacted to under pressure.

Table 4.   Checklist for setting up a usability analysis in the NPS AWE
Observation Laboratory

1. **General**

    1.1. Reserve the AWE Observation Lab well in advance.

    1.2. Confirm the date and time with all participants and others involved.

    1.3. Open HSIL main room (GL-221, phone 656-3138), participant (GL-221a), and observer (GL-216, phone 656-3134) rooms.

        1.3.1. Check lighting and inspect area for cleanliness and safety issues.

        1.3.2. Secure any equipment, papers, etc. that could interfere with your session or confuse participants.

        1.3.3. Put up "RECORDING IN PROGRESS" signs and inform others in the area of your work.

    1.4. Review the script or run profile(s) for the observation(s) to be made.

    1.5. Brief participant(s) on cameras, microphones and general lab procedures.

    1.6. Ensure consent forms are properly filled out and on file.

2. **Set up participant room (GL-221a)**

    2.1. Arrange furniture in accordance with script. Pay attention to camera locations and try to keep the participants' normal movements from blocking the cameras. Tape marks on the floor to indicate where participants should stand.

    2.2. Have an assistant stand on the marked spot while you preset the camera positions.

    2.3. Provide paper, pencils, and other props (as required).

    2.4. If used, turn on computer (power strip, CPU, display).

    2.5. Participant workstation operations check (as applicable).

3. **Set up observer room (GL-216)**

    3.1. Have script, notepad, and pens available for taking notes during the session.

    3.2. Turn on power to three surge protectors, power button on computer.

    3.3. Visually check that power is on to: surge protectors, computer, computer speakers, printer, event logging keyboard, two amps, VCR, two monitors, camera controller, and video mixer.

    3.4. Log on to the Observer workstation as **Noldus Observer** (no password required).

5.   Challenges in Coordination

A usability experiment, by nature, involves human test participants, unfamiliar tasks, and untested equipment. The researcher should always prepare for unforeseen and time-consuming delays in bringing these pieces together.

When conducting any study involving human participants, researchers should do their utmost to incorporate flexibility around the participants in all phases of the study. The experiment should impose minimal demands on test participants. Their interest in participation (and suitability as participants) wanes quickly if they must wait excessively due to equipment malfunctions or scheduling conflicts. Participants may be unavailable during the planned testing period.

While the usability researcher may be expert in running a usability test, the specific tasks used in the experiment may be wholly unfamiliar. Pilot studies are key in identifying the missing pieces of task descriptions that were left out during subject matter expert interviews. The usability researcher is not likely to become an expert in an unfamiliar domain during the experiment, but must have at hand precise and replicable definitions of all tasks, conditions, and standards. These should be reviewed extensively with the research sponsor or other domain expert to ensure that the experiment will actually observe and test the tasks and behaviors of interest.

The researcher should not strive to become a technical expert on the product or device being evaluated. Many products tested will be unstable prototypes or highly technical in nature. A domain expert on the device should be on hand to train participants, setup and troubleshoot equipment, and review the test scenario for practicality. It is inadequate and unrealistic to expect that the researcher conducting usability assessments on a device will master it in a short time, teach it to participants, and set up and troubleshoot it during the experiment. The effort this requires will inevitably result in negative compromises in either the scope of usability test or the correct employment of the equipment, and most likely in both areas. Convincing sponsors and other agencies to provide

proper support for the equipment to be tested was a major challenge during this research effort, but should be vigorously pursued. During this research, the technical experts quickly removed roadblocks to success that would have been otherwise insurmountable.

A domain expert may also advise the usability researcher on the event triggers and the range of subsequent behaviors likely to be observed. The usability researcher must assiduously maintain his or her impartiality during this relationship. The domain expert will often be an advocate or developer of the product being tested, and their motivations and biases must be recognized and acknowledged at every step of the experiment. Most developers are professionals and unlikely to intentionally or maliciously conceal negative aspects (or overly emphasize positive characteristics) of their products. However, they will still hold assumptions and goals that may interfere with their objectivity. Corporate representatives may habitually offer gifts or favors that should politely, but invariably, be declined.

The demands of external coordination are directly related to the degree of external validity sought. While frustrating, time-consuming, and generally outside of researcher's area of expertise, bringing external realities into the laboratory environment will enhance the credibility of the research and the applicability of the final results.

G.   ANALYTICAL STRATEGY

Collected data should be reviewed before analysis. The variability introduced by involving real human participants and developmental stage equipment demands much time be spent in scrubbing data for accuracy and acceptability. The validity of a specific data point may be questionable due to improper data collection procedures (such as improper experimental design), data entry errors (such as coding errors). Fortunately, because most of the data collected will have been recorded to video (potentially from multiple camera

angles), it is often possible to review the original data sources and correct data entry errors.

It may often be the case that groups of participants or specific equipment will only be available during limited time windows. Each piece of equipment to be tested will require participants spend training time specifically for that equipment, so if participants are to use more than one device, they will spend more time in training. Within these constraints, it may often be difficult to arrange within-subjects experimental designs. Worse yet, participant groups of convenience used for a between-subjects design, and obtained at different times, may not be random samples of the larger population.

Within the many practical constraints, the most likely experimental design for military individual equipment usability testing is a between-subjects design, with randomized groups of unequal sample sizes. High between-subject variability should be expected. Potentially, this individual variability may be accounted for using pre-operation surveys of technical and military experience, or by testing the users in some standard, related tasks to establish baseline capabilities.

The data gathered with a purely between-subjects design can be compared with a traditional ANOVA model (Figure 6), or a non-parametric test like the Kruskal-Wallis test. Non-parametric analysis provides protection against non-normality of the data (a strong possibility in human performance measures) and more statistical power in data sets with low numbers of participants. However, non-parametric analysis may not be possible with the more complicated experimental designs (such as odd combinations of within-subject testing) that may result from last-minute adjustments.

$$y_{i,j} = \mu + \alpha_i + \beta_j + \varepsilon_{i,j}$$

where:

i	the device tested
j	the participant #
$y_{i,j}$	the task time for participant j with device i
α_i	the device effect for device i
β_j	the participant effect for participant j
$\varepsilon_{i,j}$	random error $\square$ $n(\mu,\sigma)$

Figure 6.   ANOVA Model for Usability Measures

The hypothesis tested is given in Table 5. The measures of performance used will most often be speed (task time) and / or accuracy (# of errors, or error rate).

Table 5.   Research Hypothesis for Equipment Testing

H₀: Users perform the tasks equally well using the different equipment.

H₁: Users perform differently using the different equipment.

If the ANOVA or Kruskal-Wallis tests detect a difference between the devices, they should be followed by Tukey's multiple comparison test or the appropriate non-parametric multiple comparison, to then rank the equipment.

IV.   CASE STUDY

A.   INTRODUCTION AND RATIONALE

The purpose of this case study is to demonstrate the applicability and validity of the Applied Warfighter Ergonomics Observation Laboratory for usability testing of military individual equipment. Four different Ruggedized Personal Digital Assistants (RPDAs) were obtained and their hardware and software user interfaces compared. According to the equipment developers, during their research and development phases, the RPDAs have been evaluated primarily using "next-bench design"; i.e., an engineer who most likely has unusually sophisticated technical, but no military experience, presents an interface or prototype to a similar engineer at the "next bench" over, who then gives the designer his or her feedback.

An additional goal of this case study is to serve as a template for similar studies in the future. Notes on administrative and logistical minutia are included where they might facilitate future studies. A tremendous amount of time was spent during this research correcting problems that might be avoided by following the recommendations given here.

The RPDAs were provided by manufacturers and the associated military program offices[2]. RPDA-D was the first device tested, because it was the first available in a complete and testable configuration. Initial support for the device was provided by Captain Francisco Caceres, USMC. Captain Caceres configured and provided three fully functional devices with 1:250,000 maps of the Monterey Peninsula. Unlike the other single-unit devices, RPDA-A consisted of a small, lightweight handheld unit, connected by cable to a large central unit, which is further connected to the communications unit with more cables. The

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[2] In this report, the four devices tested are identified simply as RPDA-A, RPDA-B, RPDA-C, and RPDA-D. The actual device names and manufacturers are held as For Official Use Only, and can be obtained from the Operations Research Department at the Naval Postgraduate School.

associated hardware required by RPDA-A was carried in a backpack. Like RPDA-A, RPDA-B and RPDA-C consisted of a single unit. Unlike the other units and civilian PDAs, RPDA-C does not have a pressure-sensitive screen. RPDA-C uses a magnetic inductive stylus and a physically more durable screen than other PDAs. RPDA-B used the same hardware platform (including screen and stylus) as RPDA-C, but with a subset of the software build used in RPDA-A loaded onto it. Configured in this manner solely for experimental testing, RPDA-B had greatly reduced functionality compared to the other RPDAs. Therefore, RPDA-B was not tested using a full tactical scenario. Rather, the same group of participants learned RPDA-A and RPDA-B together (because those devices used similar software). Each participant in this group used both devices (A and B). To counter the order effects, a crossover design with random assignment determined whether participants used RPDA-A or RPDA-B first.

B. METHOD

1. Participants

The intended users of the four different RPDAs analyzed include U.S. Army Special Forces, U.S. Army Rangers, U.S. Marines, and members of the U.S. Army regular forces. Participants for the RPDA studies were drawn from Army and Marine Corps students in "casual" status (students not currently in training for various reasons) at the Defense Language Institute (DLI) at the Presidio of Monterey (POM). These students are generally junior enlisted personnel in the intelligence fields awaiting formal language training. Other participants considered included students at the Naval Postgraduate School (NPS) and service members from the actual units receiving the RPDAs. Although a convenient pool, NPS students were rejected since, as a group, they are entirely officers with high military proficiency and experience, and tend to be more sophisticated computer users. Many attempts were made to work with actual members of the units intended to receive these devices, such as Army Rangers. Operational commitments during 2004-2005, when upwards of 176,000

service members were deployed in Iraq for an average of 320 days each, precluded personnel being available for academic research.

Working with actual participants from a targeted population (as opposed to a population of convenience, such as other NPS students, or local civilians), introduces a number of challenges to coordination and logistics. For example, one-third of the DLI students initially selected, trained on a specific RPDA, and ready to be tested, were withdrawn from the study at the last minute due to other demands on their time. An entirely new group had to be coordinated and trained, wasting weeks of effort. Table 6 breaks down the effort spent just in collecting the data in this study. This estimate does not include the initial time required to learn the lab equipment or any of the later data analysis. The biggest time savings could be realized by arranging for somewhat larger groups (8-15 would be ideal) and by having a separate duty expert provide support for and conduct the training on the devices.

Table 6. Estimated Time Spent in Data Collection	
Activities per device tested	**Est. Time**
Coordinate training and acquisition with owning agency	4 hrs
Learn to set up, operate, and troubleshoot device	8 hrs
Configure and set up lab for testing	1 hr
Develop, plan and rehearse training for participants	6 hrs
Activities per testing group of 3-10 participants	
Coordination with parent unit or agency	1 hr
Transportation and classroom logistics	2 hrs
Conduct training and practical application	3 hrs
Distribute and collect surveys and consent forms	0.5 hrs
Refresher training on testing day	0.5 hrs
Activities conducted with each participant	
Set up lab equipment for this run	0.25 hr
Run scenario	0.75 hr
Coding each run	1.5 hr
Approximate total time spent	
With 4 devices, and 4 groups of 3-6 participants	120-150 hrs

There were complications in this study due to high participant attrition and reduced availability of those participants who were able to take part in the entire study. For example, the first group of participants (using RPDA-D) consisted of 19 individuals, including Soldiers, Marines, NCOs, and Officers. After having invested about 30 hours in coordinating and conducting their training, the 14 junior enlisted soldiers were withdrawn from the study for a work detail, leaving only an officer, an NCO, and the Marines.

2. Apparatus and Instruments

The laboratory equipment described in Part II was used for this case study. Appendix J contains a detailed description of the settings of each piece of equipment and software used during the case study. More general notes about the setup follow.

a. Recording Video

It is important follow the checklist in Table 4. Failure to do so usually resulted in some sort of problem. An "X" taped to the floor marked a location in the lab where the participant would stand and be in a good view from both cameras (front and side). The ceiling microphone was strung over that spot, suspended approximately seven feet from the floor. Audio equipment (microphone gain and loudspeaker volume) were checked every time, as these settings are often changed between participants or between days.

One of the most useful views of a participant using a handheld device is a split-screen shot, with the participant on the left side of the screen and a view of the equipment they are using to their right (see Figure 7). To accomplish this, the Mobile Device Camera (MDC), observing the RPDA's screen, was carefully adjusted to capture the RPDA screen butted up against the extreme left side of the camera's view. Then, the video mixer was set (transition #7) to push input 3 (from the MDC) across input 1 (the front camera), just until the entire RPDA screen was in view. Finally, the camera controller is used to adjust camera #1 until the participant is appropriately positioned in the remaining

area. There are two important items when the video mixer is set up in this fashion. With the T-bar in an intermediate position: 1) the inputs cannot be changed (you cannot switch to camera 2, for example), and 2) you must be very careful not to nudge the T-bar, as this will throw off your split-screen shot.
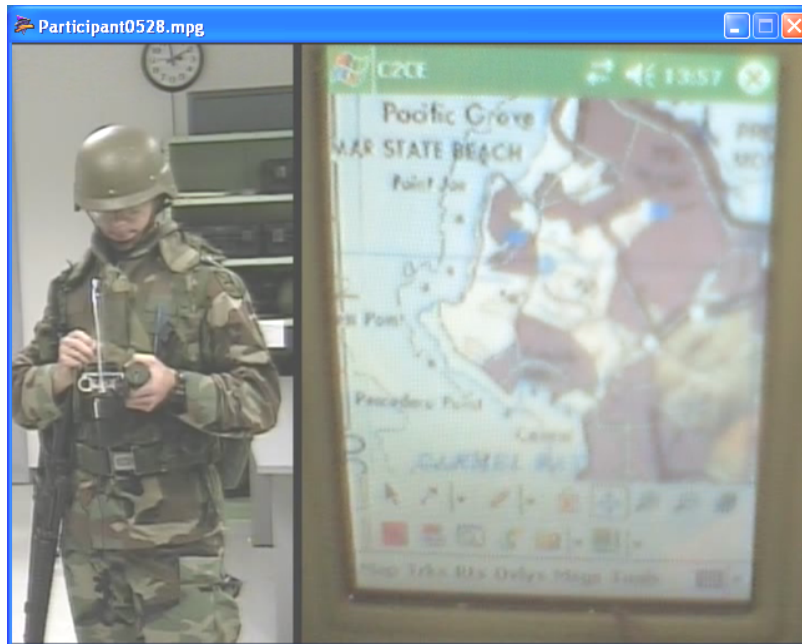
Figure 7.   Participant and RPDA Split-Screen View

The wall-mounted cameras were adjusted and presets for each camera reset for each individual participant to account for differences in height. This initial setup took about five minutes per participant. Each recording session began with the participants stating their participant ID number, to facilitate organizing the videos later.

3.   Procedure

During Tactical Network Topology field experiments at Camp Roberts, interviews and focus groups were conducted to determine how users perceive the usability of military PDAs, their current and potential functionality, and what barriers exist to adoption. A functional task analysis of users operating RPDAs was conducted. The results of the functional task analysis lead to the

development of the scenario and the specific tasks, conditions, and standards with which to perform the usability testing.

The RPDAs were compared using a between-subjects experimental design under laboratory conditions. RPDA-D was the first device tested. A group of 19 participants, including staff and students in casual status at DLI, were trained by Captain Koichi Takagi USMC, 1LT Derek Read, USAF, and 1LT Matt Simpson, USAF, in a classroom on the Presidio of Monterey. All of the classroom instruction was recorded and is available on DVD from the Applied Warfighter Ergonomics Center at the Naval Postgraduate School. First, a description of the research was presented (see Appendix H), and administrative details were addressed. Using the Noldus Mobile Device camera attached to an RPDA-D unit, Captain Takagi conducted a fifteen-minute class on the functionality and procedures for operating RPDA-D. After that, the students paired off and practiced the user tasks using the Monterey peninsula maps loaded onto RPDA-D, and the practical application test sheet given in Appendix G, section 5. While waiting to use the few RPDA units available, the rest of the students practiced their conventional skills using paper maps, protractors, and the same points on the map to be used in the test scenarios.

The primary hypothesis tested using this procedure is shown in Table 7.

Table 7. Hypothesis H_1: Differences between RPDAs
H_0: Users perform the tasks equally well using the different RPDAs.
H_1: Users perform differently using the different RPDAs.

a.   *Interviews and Focus Groups*

An ad-hoc, non-attributional military PDA focus group was conducted 1600 – 1730 on 22 Feb 2005, at Camp Roberts, CA during a Tactical Network Topology field exercise. The participants were: three senior Special

Forces staff NCOs participating in a military RPDA evaluation exercise, one representative from USASOC program office (but not the Mobile Access Infrastructure program office responsible for military PDAs), and one employee of an RPDA development company.

The goal was to determine possible requirements and capabilities for handheld military computing devices (military PDAs) in a "brainstorming" environment. Ideas were encouraged regardless of current feasibility or real applicability. Appendix J contains a free-form description (but not a verbatim transcript) of the topics discussed, including possible operational requirements for military PDAs, general and specific functionality that military PDAs might have, possible uses for and tactical employment of military PDAs, and random comments. Some participants had not used military or civilian PDAs to any great extent, some were unfamiliar with the military tasks discussed. Non-attribution was emphasized, and it was understood that the discussion would not generate obligations by the contractor or the government.

b. Surveys

The pilot surveys were given to other NPS students and evaluated by Dr. Nita Lewis Miller and Dr. Jeff Crowson during the OA3402 Research Methods course. Over a several month period, several revisions of the pilot surveys were evaluated for brevity, clarity, and relevance. As a result of the pilot surveys, questions were rewritten, response anchors revised, the format was cleaned up, and several questions were discarded. The final form of surveys captures the participant responses with minimal demands on the participant (for time and recall) and the researchers (for coding and interpretation). Due to discrepancies in how questions were interpreted between participants, the wording of several questions was slightly modified between groups. In some cases, this precludes direct comparison of the survey results between the groups. For example, question number 22 on the Technology Experience Survey originally read, "I send and receive email messages _____ times per week." This question was answered consistently during the pilot surveys, where the

administrator was available for questions. The participants during the case study took the surveys home. Some answered in terms of number of email sessions, and some in terms of individual messages. The question, and all similar questions, were changed to read "I send and receive email messages _____ hours per week." Although this renders the actual data from those survey questions invalid, the survey is now more robust for use in future studies.

Organization of paperwork required for this research was facilitated with a portable filing system using separate, color-coded manila folders labeled as shown in Table 8.

Table 8.   Surveys and Related Paperwork
1.   Prepared packets (paper-clipped packets to hand out to participants, containing all the necessary blank forms 2-6 below)
2.   Participant Information Forms
3.   Maps to NPS
4.   Blank Participant ID Forms and Participant ID Cards
5.   Blank Consent Forms (3 pages)
6.   Blank Technology Experience Surveys
7.   Blank Handheld Device Evaluations
8.   Briefs and Lesson Plans
9.   Teaching Materials and Practical Application Handouts
10.   Scenario Maps and Instructions
11.   Completed Consent Forms
12.   Completed Participant ID Forms
13.   Completed Technology Experience Surveys
14.   Completed Handheld Device Evaluations

Pre-operation Surveys. Users completed the Technology Experience Survey (Appendix E) before using the equipment to assess their

demographic background, relevant technical experience, and relevant military skills. Although it had been administered in several previous pilot studies, during this study, the survey was adjusted in several ways as described above. Some questions therefore cannot be directly compared between users.

        Post-operation Surveys. Users completed the Handheld Device Evaluation (Appendix E) after using the equipment to obtain quantitative and qualitative feedback from the user on the devices. The survey results were used in conjunction with the usability testing to determine how well users' impressions of their performance and satisfaction with the equipment corresponds to their measured performance. The primary measures of interest on this survey are overall satisfaction with the device, and a rating of ease-of-use. Many questions on this survey are intended to be broadly applicable to field use of RPDAs and other devices, and so elicited "Not Applicable" responses in the laboratory testing.

c. Usability Observations

        Tasks. The basic tasks listed in Table 9 were chosen as being tactically relevant, familiar to typical users, easily taught in a brief session, performed by both current technology and RPDAs, and common to all of the devices studied. Table 10 and Table 11 list tactical tasks that were identified as being of possible interest to similar studies.

Table 9. Basic Tactical Tasks Used in this Study
1.   Perform a communications check.
2.   Plot a route with two legs.
3.   Read three grid coordinates from a map.
4.   Determine the bearing and range from one point to another, and the total distance of a route.
5.   Send a message.
6.   Receive a message.
7.   Retrieve and read back a previous message.

Table 10.   Tasks considered, but rejected from this study
1.   Interpret streaming video data. This task was rejected as not being performed by existing technology, and not immediately familiar to typical users
2.   Send / receive digital voice messages (Voice over IP or other technology). This task was rejected as not being implemented by all RPDAs, and as unlikely to be a major decision criteria for any RPDA. Users were emphatic that they would prefer to use existing voice communication radios. RPDA digital communication links may not be well-suited for critical voice communications for because of the propagation characteristics of the radio frequencies used.
3.   Send / receive sophisticated map overlays or multimedia files. Although of considerable tactical relevance and interest, this task was rejected as being overly complicated to teach to users.

Table 11.   Tasks for consideration in future studies
1.   Receive a situational update, and brief it to subordinates.
2.   Create a tactical map overlay.
3.   Send a map overlay.
4.   Observe a video or situation and send an intelligence report.
5.   Make a tactical assessment based on tactical images or video received.
6.   Receive and process intelligence reports.
7.   Establish a (currently non-existing) communications link.
8.   Send standard tactical messages (medevac, nine-line brief, call-for-fire, etc.)
9.   Send administrative or logistic messages.

The users performed these tasks both conventionally, (for example, reading a standard paper military 1:50,000 scale map), and using alternate means; in this case, using an RPDA. The research hypothesis of this within-subjects experimental design is shown in Table 12. During the course of the study, it was found that users performed the tasks in very different ways, requiring several individual navigation tasks to be combined into a single larger

measurement of mapping skill. Therefore, the conventional and alternate tasks no longer corresponded well with each other, and the hypothesis presented in Table 12 could not be directly tested. To address hypothesis H_2, the test scenario must be designed in tight conjunction with the device capabilities and tuned in pilot studies to ensure that the tasks correspond well between the conventional and alternate means. The seven chosen tactical tasks were coded for data entry as shown in Table 13.

Table 12. Hypothesis H_2: Conventional vs. Alternate Means
H_0: Users perform the tasks equally well using conventional and alternate means.
H_2: Users perform differently using conventional and alternate means.

Table 13. Coded tactical tasks

Task #	Description	Means	Abbreviated Description
1	Perform a communications check	Conv. Alt.	1c comm chk 1a comm chk
2	Plot a route with two legs	Conv. Alt.	2c plot rte 2a plot rte
3	Determine the grid coordinates of three locations from a map	Conv. Alt.	3c read grid 3a read grid
4	Determine the bearing and range from one point to another, and the total distance of a route (when supported)	Conv. Alt.	4c brg rng 4a brg rng
5	Send a message	Conv. Alt.	5c send msg 5a send msg
6	Receive a message	Conv. Alt.	6c rcv msg 6a rcv msg
7	Retrieve and read a previous message	Conv. Alt.	7c read back 7a read back

As the testing progressed, inconsistencies were noted that required the task definitions and scoring standards be re-defined. For example, in the first part of the scenario, participants were instructed, in three separate steps, to plot a

route, to read three grids, and to compute a bearing and range. Although the first group of participants performed the task consistently, subsequent participants would sometimes calculate all the required information in the first step, so that the task time for the first step was much longer, and the subsequent task times were virtually zero. The task was then re-defined and the observations were re-scored to collect all the task time of the three steps into a single task, whether they had broken it up or not. Although some granularity is lost in doing this, the task can now be reliably compared between participants.

Another problem arose only after observing many participants. During the initial and refresher training and practical application, about ten points were identified on the paper and PDA maps including all six of the points used in the scenario. During the testing phase, some participants were still confused about some of the locations, especially the Monterey Airport. This confusion resulted in extremely long task times as the participants scrolled around the PDA screens in a fruitless search. When directed to the location, they were able to complete the task. These data points are outliers in the sense that the are the sum of two behaviors: tactical skill task time (the behavior of interest), and search time (an error term). Rather than discard them completely, the navigational tasks were redefined as "off-task" after the participant had been subjectively judged as "lost" for more than five seconds. Indications of lost behavior include looking directly at the target and then away from it, and searching in an entirely wrong direction for more than five seconds. Subjective measures of off-task behavior such as these should be avoided in future studies by fully inoculating participants against confusion during tasks. In this case, more explicitly training participants to the locations of interest may have helped. Inter-coder and intra-coder reliability analysis was used to ensure that the subjective correction applied (defining lost behavior as off-task) was applied consistently.

Other observed behaviors: errors and posture. In addition to the tasks observed, the five categories of error listed in Table 14 were coded as they occurred.

Table 14. Errors by Type

Error	Description	Abbreviated Description
1	Slip: unintended action, user realizes error	slip
2	Mistake: intended action, user is unaware of error	mistake
3	Device error: the device fails or crashes, not due to user action	device err
4	Interface error: user has a problem with device input or output, such as getting device to register input, or reading labels or screens	Interface err
5	Equipment handling error: due to using this device, the user spends time correcting equipment or has a physical difficulty handling or operating any piece of gear, such as dropping rifle, untangling cords, etc.	eq handle err

The tactical postures described in Table 15 were coded as they occurred. The specific criteria for a tactical (vice administrative) posture was: shooting hand on the pistol grip of the weapon and able to engage in less than one second, otherwise define state as admin posture.

Table 15. Tactical Postures

Tactical Posture	Description	Abbreviated Description
1	Tactical: The participant is immediately ready for a combat situation, shooting hand on the pistol grip of the weapon and able to engage in less than one second	Tactical
2	Administrative: The participant is not immediately ready for a combat situation, for example, with his weapon slung over his shoulder.	Admin

The conventional segment of the scenario was identical for each RPDA. The RPDA segment was intended to be identical for each RPDA. Some RPDAs were not available at the time the scenario was written, and the scenario was adjusted slightly to accommodate different capabilities. This prevented between-device comparisons in those specific tasks, but the majority of tasks can still be compared between devices. The tasks that had to be modified can still be compared to the baseline performance using conventional equipment.

Conditions. Laboratory testing took place at the Naval Postgraduate School, in the Applied Warfighter Ergonomics laboratory in Glasgow Hall room 221. Environmental conditions and personal characteristics of the participants not explicitly listed, were not measured. Environmental conditions, such as lighting and temperature, were constant, comfortable, and typical of an office environment. All testing occurred between 8:00 am and 6:00 pm on weekdays.

Test participants wore their own camouflage utility uniforms and the older model combat equipment[3] listed in Table 16.

Table 16.   Battle Gear Worn in the Tactical Scenario

Item #	Description	Abbreviated Description
1	Kevlar helmet	helmet
2	Kevlar flak vest	flak
3	Load-bearing vest with magazine pouches and canteens	LBV
4	Rubber M-16A2 rifle	weapon

Standards: Measures of Effectiveness and Measures of Performance. Each task has a precisely defined measure of success defined in Table 17. All tasks start as soon as the verbally issued instructions are completed, for the first time, if the instructions are repeated. If the instructions were completely unintelligible to the participants, then task start is when the instructions are issued comprehensibly.

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[3] Individual equipment was temporarily loaned from the Marine Corps Detachment at the Defense Language Institute. Considerable time was spent unsuccessfully attempting to obtain current-issue equipment.

Table 17. Measures of Task Success

Task	Measure of success
comm chk	Participant verifies that 2-way communication is established by sending and receiving a simple message.
	Task ends: participant completes saying or typing "comm check"
plot rte	Participant performs a basic land navigation task, including plotting a route with two legs, recording the three grid coordinates (endpoints and middle waypoint), computing the bearing and range of the first leg, and the total distance of the route.
	Task ends: participant begins reading the completed information. Recorded as "off-task" while actually reading information out loud.
	Off-task when participant has been "lost" on map for five seconds, and scrolling around only because they cannot find a location.
read grid	Participant computes a six-digit grid coordinate within plus or minus 500 meters. This large leeway is due to imprecision in identifying certain landmarks on the military topographical maps.
	Task ends: participant begins reading the completed information. *Off-task when participant has been "lost" on map for five seconds, and scrolling around only because they cannot find a location.*
brg rng	Participant computes a bearing within plus or minus 2 degrees and a range within plus or minus 500 meters. Total distance also will have an accuracy of plus or minus 500 meters or 5%, whichever is higher.
	Task ends: participant begins reading the completed information. *Off-task when participant has been "lost" on map for five seconds, and scrolling around only because they cannot find a location.*
send msg	Participant sends a message that would be unambiguously understood by another military member in the current context. Abbreviations and tactical terminology are acceptable.
	Task ends: participant completes reading the message out loud.
rcv msg	Participant demonstrates that he or she understands a message by either performing an instruction or reading it aloud to the notional patrol members. Paraphrasing is acceptable if the precise meaning is retained.
	Task ends: participant indicates that they have understood the message by performing an appropriate action, or when they have completed copying down information.
read back	Participant locates and reads back a message previously sent or received that he or she would not likely be able to recall from memory.
	Task ends: participant begins reading the message out loud.

The metrics used to evaluate behaviors were task time, number of errors by type, and tactical posture. Task time began when the

scenario narrator finished reading the task (the first time, if a long instruction was repeated). Task time ended (that is, the participant was coded as "off-task") when the participant began the next behavior, which was usually reading something (like a grid coordinate) aloud to his notional patrol members. There were occasions when task completion times is in doubt, usually because the participant appears to have cognitively moved off the task, but forgot to perform the ending behavior. For example, when reading a message on the RPDA, the task ending behavior is to read the message aloud to the notional patrol members. Occasionally, the participant would read the message but not read it aloud, although he or she clearly had understood the message and would then read it aloud when prompted. A "best-guess" in these situations would mark the end of task time.

Another ambiguous behavior to code was in exercising paper mapping skills. When given points on a map, some participants simply wrote down the points and awaited further instructions (the desired behavior). The next tasks were to plot the points and read the grid, and then to plot the route and read the bearing and range of just the first leg. Some participants performed all the tasks, as well as computing the bearing and range of all legs (rather than just the first), in a single step. This made it impossible to separate out task times into times for performing each of the individual tasks. Therefore, the routine originally envisioned as three separate tasks (plot route, read grid, compute bearing and range), was collapsed into a single longer task (plot route), with the task time starting and stopping when the participant was reading the data or receiving instructions.

Scenario. The scripts for the tactical scenarios presented are detailed in Appendix F. The scenario used a second computer running a tactical decision-making game presented to the test participant on a 52" plasma screen with stereo speakers. The software used is called Combat Decision Range (CDR), and developed by the Marine Corps Warfighting Lab. The CDR was run on a laptop computer with S-video output driving the plasma screen in the other

room. The S-video output was also split off to input four of the video mixer for monitoring from the Observer room.

Combat Decision Ranges (CDRs) were designed to present tactical scenarios to squad and platoon leaders in the Marine Corps. The CDRs present stressful situations demanding quick thinking by the participant. Within this study, the CDR was used to build a combat mindset in the participants. The tasks triggered for the usability study were very specific, and the participant was not allowed freedom of decisions such as the CDR was designed for. Therefore, there was an artificiality to the test environment, as the scenario was interrupted to issue specific instructions to the participant. The participants were briefed in advance that the tasks were at times tactically illogical or inconsistent with other parts of the scenario.

In the scenario designed for this study, seven tasks were triggered twice, once using conventional means and once using the RPDA (the alternate means). The key tasks were triggered more than once in the conventional and alternate means. Repeating exactly the same scenario twice would have introduced learning effects into the second performance of the task. Therefore, the situations for triggering a task, such as, "send a short message", were similar, but not identical, during the conventional and alternate phases of the scenario. Only one complete scenario, with conventional and alternate segments, was administered to the participant, and all participants experienced the exact same sequence of events.

Conducting the scenario and observation required the operation of the computer playing the scenario videos, operating the camera controller, video mixer, and computer recording the video, reading aloud the participant instructions over the microphone, and talking on a handheld radio to the participant when appropriate in the scenario. Additionally, the participants were briefed, and assisted with donning their equipment and operating the RPDA. Due to all of these issues, a research assistant was needed for all recording sessions.

C.   CASE STUDY RESULTS

1.   Interviews and Focus Groups

Interviews and focus group discussions (details in Appendix K) with the developers and program managers of the RPDAs revealed several assumptions frequently are made about the population of users:

1. Most users are comfortable with the Microsoft Windows user interface model.
2. Most users are frequent video game players (sometimes referred to as the "Nintendo generation").
3. Most users have some degree of technical knowledge about computers and networking.
4. Most users have and operate cell phones or civilian PDAs on a regular basis.

As shown in the next section, the survey results in this study have not borne out these assumptions as being entirely consistent with our test user base. Direct surveys of the actual user population of these RPDAs have not been conducted.

2.   Survey Data

The individual and aggregate raw survey results can be found in Appendix J. Several of the surveys were not turned in due to participants forgetting them or not having time to fill out the post-operation survey. Some results from the pre-operation survey about the participants in this study include:

36% do not have a cell phone (5 hr/wk median talk time for participants who have a cell phone),

50% have never operated PDA before,

54% have a computer at home,

Median age was 20 yrs old,

84% directly from boot camp,

Participants did not comment as extensively on the surveys as was hoped.

3. Usability Observations

Observations were coded in the Observer software. The Observer's elementary statistics functionality was used to create a file containing the total durations of all tasks, by individual participant and coder. This data file was exported to Microsoft Excel, where it was formatted into comma-separated value (.CSV) data files for analysis in standard statistics software. S-Plus version 7.0.3 (Insightful Corporation, 2005) was used for all statistical analysis, as described below.

rpda.orig is the unedited S-Plus data file. It contained some questionable data points: Due to time constraints, participant 504 experienced an abbreviated scenario that was not similar to the conditions used in the rest of the testing. Some participants tested two devices, in two complete, separate scenarios. A large, advantageous learning effect was presumed for the second device tested.

As shown in Table 18, the S-Plus data frame rpda removed the questionable data points from **rpda.orig**. The measurements for devices tested second were deleted. Participant 504's data were deleted.

```
                Table 18.  The S-Plus data frame rpda
> rpda=rpda.orig[(rpda.orig$order==1) &
       (rpda.orig$id != 504),]
> attach(rpda)
> dim(rpda)
[1]   10 114
> rpda[,0:12]     # a sample of what the data looks like:
     id dev order   z1  z2    z3     z4   z5 z6   z7 t1 t2
 2 502   1     1  8.0 264  40.0  78.0 15.0 30 14.0 74 NA
 5 505   1     1 14.5 290  31.0 112.5 15.0 44  6.0 40 NA
 6 506   1     1 14.0 321  29.0 111.0 23.0 51 18.0 26 NA
 7 501   2     1  5.0 502 100.0  89.0  5.0 52  3.0 NA NA
 9 503   2     1 16.0 318  23.0  49.0 25.5 32 32.5 NA NA
13 513   4     1 30.5 307  32.0  80.0 15.5 21 12.0 22 55
14 514   4     1 11.5 258  12.0  85.5 36.5 43 11.0 22 46
15 515   4     1 15.0 286  31.0  84.0 15.0 18  5.0  2 92
16 527   4     1 10.0 189   2.5  37.5 63.5 29  3.0  1 46
17 528   4     1  7.0 231   5.0  38.0 18.0 27  1.0  1 42
```

Measurements were times (in seconds) to complete a specific military task. There were seven tasks, as described in Table 13. Conventional tasks were denoted tasks z_1 through z_7. Tasks performed on the RPDAs were denoted t_1 through t_7. The tasks were generalized into mapping skills tasks (t_2 – t_4) and communications tasks (t_1, and t_5 – t_7).

A device may perform well on some tasks, but poorly on others. In some cases, it was possible to move functionality from one device to another, to create a new device that performs some tasks like RPDA-A, and other tasks like RPDA-D. Therefore, the best performance in each task individually was of interest, rather than an overall rating of the devices. Using separate evaluations for each task also allowed decision makers to decide for themselves which were the most important tasks.

Tasks 2, 3, and 4 were very closely related mapping skills tasks. The conventional measurements were treated as three separate measurements of mapping skills, and combined into a single mapping skills score. They were all adjusted to the scale of conventional task 2 (the z_2 measurements), and averaged as shown in Figure 8:

$$mapskill = \frac{1}{3}\left(z_2 + \frac{\tilde{z}_2}{\tilde{z}_3} z_3 + \frac{\tilde{z}_2}{\tilde{z}_4} z_4 \right)$$

```
> rpda$mapskill = (z2    + median(z2,T) / median(z3,T) * z3
                   + median(z2,T) / median(z4,T) * z4 ) /3
```

Figure 8.   Mapskill Function (algebraically and S-Plus code)

The medians, rather than the means, were used for scaling, as the measured task times have heavy right tails. The participants with the longest task times also had the greatest variability in time, and the median was chosen as a more stable estimate of central value.

The **mapskill** score was used as a composite measure of an individual's conventional mapping ability. It had the advantage of incorporating three separate measurements from an individual. The graph below, and the regressions following it, show how the **mapskill** score was related to the individual z_2, z_3, and z_4 measurements, and how those skills were related to each other.

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```
> pairs(rpda[,c("mapskill","z2","z3","z4")],pch=16,cex=1)
```

```
> summary(lm(z2~mapskill,data=rpda))
Multiple R-Squared:      0.888
F-statistic: p-value is      0.000
> summary(lm(z3~mapskill,data=rpda))
Multiple R-Squared:      0.946
F-statistic: p-value is      0.000
> summary(lm(z4~mapskill,data=rpda))
Multiple R-Squared:      0.398
F-statistic: p-value is      0.050
```

Figure 9.   Pairs plots of mapskill, z_2, z_3, and z_4
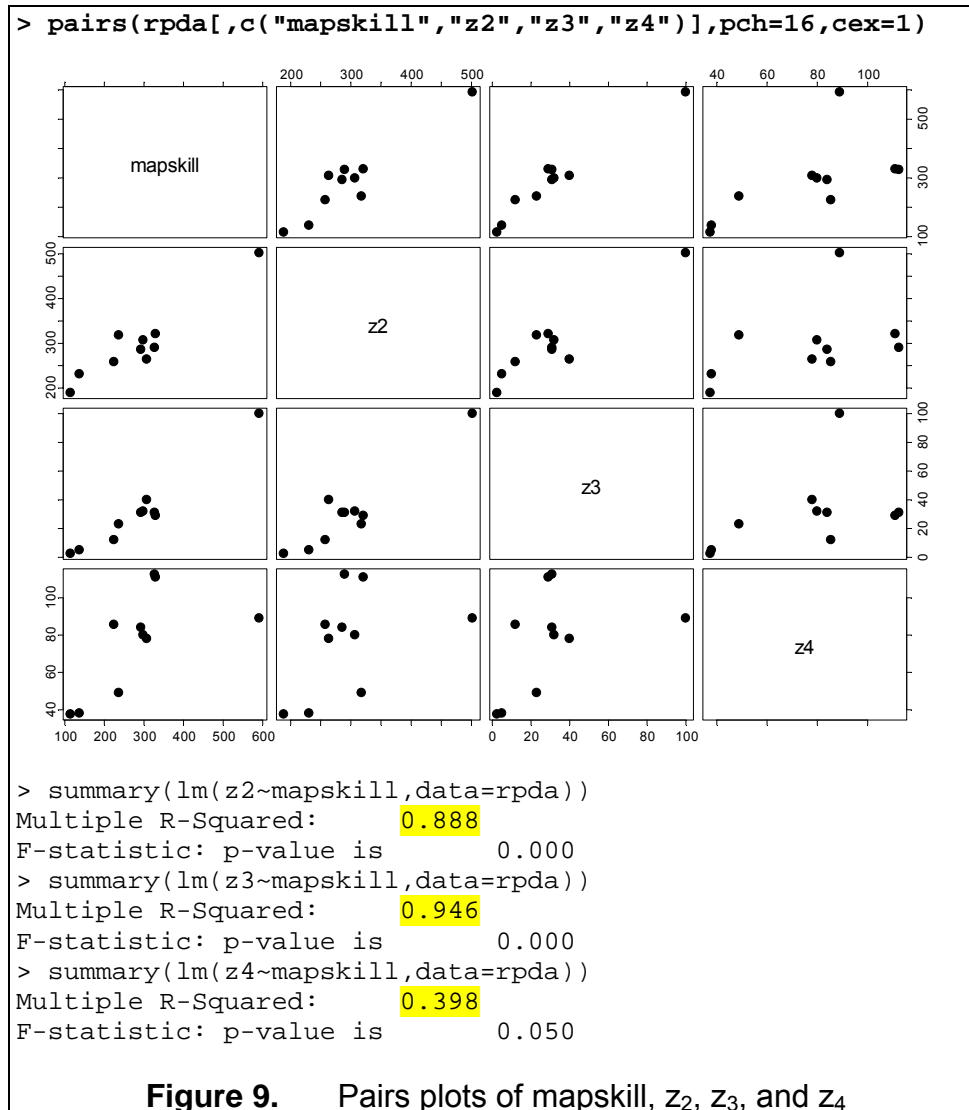
Participant skill in mapping tasks on an RPDA was expected to be partially related to their skill in performing similar tasks using conventional means. The plots below show that there may be some component of `mapskill` in the measured task times z_2, z_3, and z_4. These plots also show that the tasks themselves may be independent of each other, and also that there were some measurements with extremely long task times, relative to the other tasks.
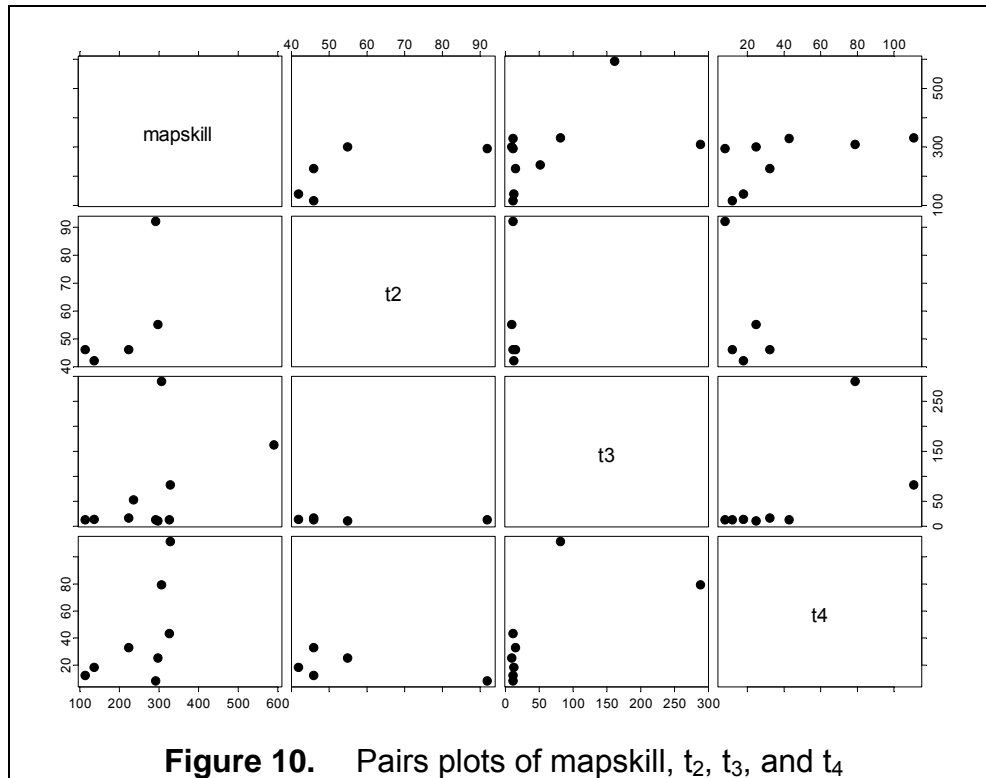
Figure 10. Pairs plots of mapskill, t_2, t_3, and t_4

If a statistically significant difference is found between the devices, the cause of the difference may be that one device is actual better than another. The most important reason a difference might be seen, other than due to the different devices, is that participants are different from each other. If the groups testing each device appear to be dissimilar due to small sample size or inspection of the participants, an adjustment must be made for participant effects.

A naïve heuristic for adjusting for this participant effect is to form a ratio of the RPDA task time to the mapping skill score (which are both times in seconds). The results of this study do not directly support this transformation, however, it is proposed as a way to move forward with the evaluation while adjusting in some way for participant effect.

```
> rpda$t2adj = t2 / mapskill
> rpda$t3adj = t3 / mapskill
> rpda$t4adj = t4 / mapskill
```

Unlike the closely related conventional navigation tasks (z_2, z_3, and z_4), which could be viewed as separate measurements of more general mapping skill, the communications tasks were less like each other. It is not clear that a single skill score is appropriate with them. Task times for the communications tasks are therefore adjusted directly from a ratio with the original task.

```
> rpda$t1adj = t1 / z1
> rpda$t5adj = t5 / z5
> rpda$t6adj = t6 / z6
> rpda$t7adj = t7 / z7
```

Several statistical tests for a difference between the three devices can be performed. An analysis of variance (ANOVA) model allows incorporation of more independent variables into the model, such as test order or survey responses. One possible ANOVA model in a study such as this one is given in Figure 11.

$$y_{i,j,k} = \mu + \alpha_i + \beta_j + \theta_k + \varepsilon_{i,j,k}$$

where:

i	the device tested {A, B, D}
j	the participant # {0500...0599}
k	the order tested {1 or 2}
$y_{i,j,k}$	the task time for this combination
α_i	the device effect for device i
β_j	the participant effect for participant j
θ_k	the order effect for order k
$\varepsilon_{i,j,k}$	random error $\square$ $n(\mu, \sigma)$

Figure 11.   General ANOVA Model for Usability Testing

Using ANOVA, a difference was not detected based on task 3 (read grid coordinates from a map):

```
> anova(aov(t3~dev,data=rpda))
Analysis of Variance Table
          Df Sum of Sq Mean Sq F Value Pr(F)
     dev  2     29082   14541    2.14  0.188
Residuals 7     47559    6794
```

As expected, when adjusting for participant effect, the statistical significance of the test was even lower:

```
> anova(aov(t3adj~dev,data=rpda))
Analysis of Variance Table
          Df Sum of Sq Mean Sq F Value Pr(F)
     dev  2     0.221   0.110    1.71  0.248
Residuals 7     0.452   0.065
```

In task 5 (the unadjusted time to send a message), a statistically significant difference was found (see Figure 12), and it was initially concluded that using the device RPDA-D is in fact faster than using RPDA-A (and B is also better than RPDA-A at a slightly lower confidence threshold):

```
> t5.aov=aov(t5~dev,data=rpda)
> anova(t5.aov)
Analysis of Variance Table
          Df Sum of Sq Mean Sq F Value  Pr(F)
     dev  2     16999    8499    5.57   0.0357
Residuals  7     10689    1527

> multicomp(t5.aov)
95 % simultaneous confidence intervals for specified
linear combinations, by the Tukey method
     Estimate Std.Error Lower Bound Upper Bound
A-B      98.6      35.7       -6.47       204.0
A-D      85.6      28.5        1.59       170.0 ****
B-D     -13.0      32.7     -109.00        83.3

> plot(multicomp(t5.aov))
```


Figure 12.   ANOVA analysis of task 5

However, when the time was adjusted by the individual's conventional task time, a difference was not seen. Therefore, the better task times may not be due to better devices, but to better operators, better training, or some other effect (see Figure 13).

```
> anova(aov(t5adj~dev,data=rpda))
Analysis of Variance Table
          Df Sum of Sq Mean Sq F Value Pr(F)
     dev  2        91    45.3    1.81   0.232
Residuals  7       175    25.0
```

Figure 13.   ANOVA analysis of task 5, adjusted for participant effect
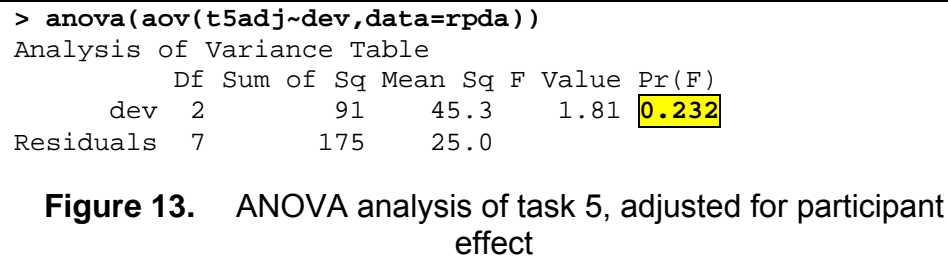
There were also slight differences in the scenario presented during the testing of RPDA-D and of RPDA-A. RPDA-B used a very abbreviated scenario with only two tasks. Although the tasks were similar, the RPDA-B scenario was not at all comparable to the scenario presented during the testing of RPDA-A and

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RPDA-B. This additional confound complicated statistical analysis to the point of making it difficult to justify with such small sample sizes.

ANOVA is subject to assumptions of normality and of equal variances. Both assumptions are highly suspect with this data. First, the data are known to *not* be normally distributed. Task times cannot fall below zero, yet some tasks have short task time and high variability. The tasks are also seen to have heavy right tails, with occasional users taking extremely long times.

When using ANOVA on data such as these, variance-stabilizing transforms may be considered to address the impact of unequal variances. These data appeared to become more normally distributed with both logarithmic and even square-root algorithms, but with the very small sample sizes, the appropriate transform is unclear.

To ensure against unwarranted assumptions, a two-sided Kruskal-Wallis rank sum test was performed on the same data. Rank-based tests are especially appealing because of the heavy tails of the distributions. Figure 14 demonstrates non-parametric testing of task 3, task 5, and task 5 adjusted for participant effect.

```
> kruskal.test(t3, dev)
Kruskal-Wallis chi-square = 4.170, df = 2, p-value = 0.124

> kruskal.test(t5, dev)
Kruskal-Wallis chi-square = 6.070, df = 2, p-value = 0.048

> kruskal.test(t3adj, dev)
Kruskal-Wallis chi-square = 3.386, df = 2, p-value = 0.184
```

Figure 14.   Kruskal-Wallis tests for device effects

When using S-Plus, Kruskal-Wallis multiple comparisons are performed manually. Since a difference was detected, the multiple comparisons were performed on the task 5 times, at a 95% confidence level (Figure 15).

```
> t5rank=rank(t5); t5rank              # compute the ranks
 [1] 10.0  9.0  8.0  5.0  1.0  6.0  2.0  3.5  7.0  3.5
> dev
 [1] A A A B B D D D D D
> R=c(0,0,0)                           # initialize array
> R[1]= sum(t5rank[dev=="A"]);R[1]   # compute the rank sums
[1] 27
> R[2]= sum(t5rank[dev=="B"]);R[2]
[1] 6
> R[3]= sum(t5rank[dev=="D"]);R[3]
[1] 22

> n=c(length(t5rank[dev=="A"]), length(t5rank[dev=="B"]),
    length(t5rank[dev=="D"])); n     # n[i] = number of obs.
[1] 3 2 5
> N=sum(n); N                          # N = total obs.
[1] 10
> k= length(levels(dev))              # number of treatments
> alpha = 0.05                        # desired confidence level

> S.squared =1/(N-1) * (sum(t5rank^2) - N*(N+1)^2 / 4);
S.squared
[1] 9.111
> T.stat = (sum(R^2/n) - N*(N+1)^2 / 4) / S.squared; T.stat
[1] 6.069
> student.t.stat = qt(1-alpha/2, N-k); student.t.stat
[1] 2.36
> constant=student.t.stat * sqrt(S.squared * (N-1-
T.stat)/(N-k)); constant
[1] 4.62
```

The following lines display the left-hand side and RHS of the multiple comparison criteria for the Kruskal-Wallis test. If the LHS > RHS, then there is a difference.

```
> i=1; j=2; c( abs(R[i] / n[i] - R[j] / n[j]) , constant *
sqrt(1/n[i] + 1/n[j]) )
[1] 6.00 4.22
> i=1; j=3; c( abs(R[i] / n[i] - R[j] / n[j]) , constant *
sqrt(1/n[i] + 1/n[j]) )
[1] 4.60 3.37
> i=2; j=3; c( abs(R[i] / n[i] - R[j] / n[j]) , constant *
sqrt(1/n[i] + 1/n[j]) )
[1] 1.40 3.86
```

Figure 15.   S-Plus Code for Kruskal-Wallis Multiple Comparisons
Tests

At α = 0.05, B is better than A, and D is better than A. However, B is no better or worse than D. As with the ANOVA test, however, if the heuristic adjustment for participant effect on task 5 is performed, a statistically significant difference is not seen:

```
> kruskal.test(t5adj, dev)
Kruskal-Wallis chi-square = 3.68, df = 2, p-value = 0.159
```

4. Inter-Rater Reliability

To verify that the measurements are objectively coded, inter-rater reliability (IRR) analysis was performed. Task time assessments by two different researchers ("A" and "B") on the same video file (participant 0513 operating device RPDA-D) are shown in the "confusion matrix" in Table 19.

Table 19.	Confusion Matrix for Participant 0513, RPDA-D							
	t1	t2	t3	t4	t5	t6	t7	Error	**Total A**
t1	22.63	-	-	-	-	-	-	0.33	22.96
t2	-	54.73	-	-	-	-	-	0	54.73
t3	-	-	9.71	-	-	-	-	0	9.71
t4	-	-	-	25.1	-	-	-	0.14	25.24
t5	-	-	-	-	92.06	-	-	0	92.06
t6	-	-	-	-	-	19.53	-	5.8	25.33
t7	-	-	-	-	-	-	5.5	0.94	6.44
Error	0	1.63	1.65	0	0.17	0	0	-	3.45
Tot.B	22.63	56.36	11.36	25.1	92.23	19.53	5.5	7.21	239.92

Table 19 shows the total duration (in seconds) scored for the seven tasks (t1 – t7) by two different coders ("A" and "B"). The actual time coded by coder A is shown in the Total A column at the right, and the actual time coded by coder B is shown in the Total B row at the bottom. The number in the matrix reflects the agreement between the two times, that is, the lesser of the two times. For example, both coders agreed that the participant spent at least 22.63 seconds on task 1. Coder A actually measured the time as 22.96 seconds. The 0.33 seconds of difference is shown in the Error column for A. Other types of inter-rater reliability analysis could have additional times in the off-diagonal cells of the confusion matrix, showing what task or behavior the coder recorded during the

times of disagreement. The frequency and sequence of observed behaviors can also be compared.

Figure 16 shows that the task times (t1-t7) assigned by different researchers (on the vertical and horizontal axes) are in very good agreement for this observation.

Figure 16.   Tasks times as coded by Rater A and Rater B
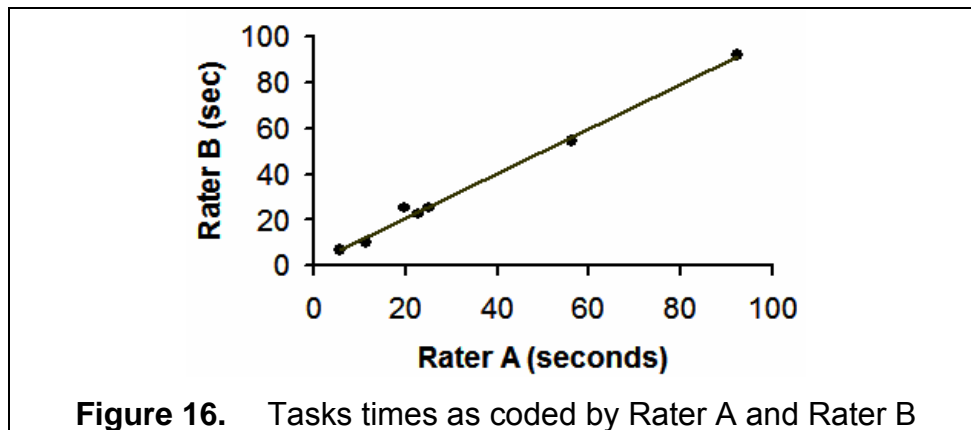
Statistics commonly used to ensure that objective criteria are being applied in scoring the behaviors include the index of concordance and Cohen's κ. The index of concordance is the proportion of agreements to total observed time. Cohen's κ is a measure of the proportion of agreement that exceeds that expected by chance (Figure 17).

$$\kappa = \frac{p_0 - p_c}{1 - p_c}$$

where: p_0 = the observed proportion of agreements
p_c = the proportion of agreements expected by chance

Figure 17.   Formula for Cohen's κ

In this comparison of raters A and B, the total duration of agreements is 229.3 seconds, the total duration of disagreements is 10.66 sec, the index of concordance is 0.96, and Cohen's κ = 0.94. This indicates that independent observers using the same instructions were quantitatively coding behavioral data in a very reliable manner. Achieving this level of agreement requires detailed and

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objective coding criteria and scenarios that provide for precisely defined task start and end points.

D.   DISCUSSION OF CASE STUDY

1.   Conclusions from Case Study

Due to the high rate of participant attrition, statistically supportable conclusions cannot be drawn from the quantitative data collected in this study. A number of usability issues were directly observed or were noted in the post-operation surveys.

    a. All RPDAs interfered with the user's ability to use their personal weapon. *(HDE 0501AB, 0502A, 0505AB, 0506A, 0515D, 0528D, RA0502 at 20:14; RA0503 at 28:15)[4]*

    b. Participants were generally not particularly satisfied or dissatisfied with a stylus input device, although some were highly opposed. Almost all participants who had negative comments about the stylus had never used one before. *(HDE 0501AB, 0502B, 0505AB, 0506A and corresponding TESs)*

    c. User satisfaction was not tied to objective performance. For example, participant 0502 was "Very Dissatisfied" with the RPDA-B stylus, and "Very Satisfied" with RPDA-A. However, he was actually faster in the messaging tasks with RPDA-B than with RPDA-A. The video shows him repeatedly tapping with the stylus using RPDA-B, which is a source of frustration but was not detrimental to his overall performance.

    d. A single incident can disproportionately affect user satisfaction with the overall device. Participant 0501 experienced a single incidence of difficulty with the stylus, but no other problems. His satisfaction with the stylus was "Very Dissatisfied", although his performance using it was average.

    e. RPDAs can bring inexperienced personnel, who performed poorly on baseline tasks, up to performance levels similar to

---

[4] The parenthetical comments indicate the survey questions or the observations that support the conclusion. Surveys are prefaced "HDE" for the Handheld Device Evaluation or "TES" for the Technology Experience Survey, followed by the four-digit participant number. RPDA observations begin with "R", followed by the letter identifying the RPDA, followed by the four-digit participant number, followed by the approximate time (minutes:seconds) in the video that the behavior was observed.

personnel who excel at baseline tasks. Participants with little military experience ("novices") required considerable training to perform the conventional mapping tasks and were generally two to ten times slower than users with high military experience ("experts"). The novices were also more likely to make errors in conventional tasks than the experts. However, novice performance using the RPDAs for mapping was comparable to expert performance. Although experts generally fared better at RPDA mapping than novices, they were only incrementally better. The novices cut their mapping skill task time by a factor of ten in some cases, while some experts actually experienced an increase in their task time compared to conventional means. *(See task 3, participants 0502, 0503, and 0527).*

f. Users commented about the bulk of RPDA-B, which was the largest one-piece unit, but expressed even stronger dissatisfaction with the RPDA-A, which had a smaller handheld piece tethered to equipment in the pack *(HDE 0501A).* Several problems (one fairly serious) were observed with the tethered cord become tangled in other equipment *(RA0503 at 28:15).*

g. Lacking feedback and appropriate error messages, users wasted much time attempting incorrect procedures. Virtually all participants indicated that if they experienced a problem using a computer, they would "keep trying" as their first step to solve it. This behavior was frequently observed *(RA0501A at 37:50)* when the device did not give feedback to the user that an inappropriate action (such as scrolling off of the edge of a map) was being attempted.

h. The RPDAs made novice users feel more confident in their mapping skill, even when their performance and accuracy were poor. *(HDE 0502A, 0505A).* This may be an example of the false pedigree of credibility that high-technology devices can carry, as discussed in the literature review (page 11).

i. The low visibility and small size of the PDA screen (72 dots per inch, low-contrast screen, compared to a 1200 dots per inch, high-contrast paper map) made it very difficult for users to search for locations with which they were unfamiliar.

2.   Recommendations from Case Study

Participants in this study had only an introductory level of proficiency and experience with the devices. Performance at this stage should not be of primary interest, except to the extent that these initial impressions make an impact on

user acceptance. Users proficient with the stylus and the software should be participants in testing usability and user satisfaction. More proficient users also have reduced intra-task variability and would provide better data for statistical analysis.

The recommendations for context-aware designs found in the introduction to this thesis (page17) have been confirmed by the qualitative results of this study:

Sensible default behavior. Users benefited from RPDAs that were organized consistently and performed appropriate actions the first time. An example of good default behavior: tapping a location on a map brings up the most likely information desired (grid location). An example of poor default behavior: when reading a message, RPDA-D required users to scroll to the bottom of the message (past header information that was never used) to get the information they want – the message text. The header information should be less prominent by default.

Restricted options. Errors were frequently seen when users are allowed to perform incorrect tasks, such as closing a necessary application, or changing vital communications settings. Users should be protected from actions that would be incorrect in most situations.

Robustness to inputs. Users became extremely frustrated when simple slips caused serious errors. Slips appeared to occur due to users having to split their attention or due to input errors with the stylus.

Informative error conditions and graceful recovery. RPDAs should provide immediate feedback to the user when inappropriate tasks are attempted, or they will likely continue to attempt that task incorrectly before trying other solutions. This behavior was reported on almost all the surveys and directly observed in many instances.

The appropriate level of detail presented on a map appears to be extremely important. Displaying multiple scales of map (for example, 1:250,000

for zoomed out and 1:50,000 for zoomed in) may help alleviate some of the confusion users experienced when zoomed out on a cluttered, highly detailed map.

Menus and action buttons should be consistent and readily visible. Users were frequently observed looking in the wrong menus for functions that appeared in that location in another application. Users do not generally want (or need) to understand that different applications may be running simultaneously (such as separate communications and navigation applications). Different applications should still maintain similar interfaces. For example, when changing between communication and navigation functions on RPDA-A, the menu selections change subtly. In the communications mode, users consistently went to the incorrect menu (which would have been the correct menu in the navigation application) to change applications.

3.   Follow-on Research to the Case Study

The framework of the study remains in place, including points of contact, method, and equipment. Adding additional data points with any of the devices, in order to allow more robust statistical analysis, should be a relatively straightforward process. Continued work with the RPDA case study may yield definitive results, allowing comparison between RPDAs, and additional recommendations for the field of RPDA design. Integrating the Applied Warfighter Ergonomics Center's laboratory and field capabilities early on in the design and prototyping of RPDAs and other military individual equipment will result in better equipment being fielded. The AWE laboratory could be used in the design of RPDAs in the following ways:

- defining the appropriate tasks to be performed by an RPDA,
- quantifying the effect of RPDA use on battlefield situational awareness (SA),
- defining the appropriate characteristics of an RPDA: device size, weight, screen size, reflectivity, brightness, resolution, and types of controls.

A number of questions surfaced during the planning, execution, and analysis of this case study that are of keen interest but beyond the scope of this study. The following topics would be excellent avenues to pursue a more detailed study using the capabilities of the Applied Warfighter Ergonomics Observation Laboratory.

Technology experience among various U.S. military populations. The Technology Experience Survey is ready to be issued in a full study, and concise enough to reasonably administer to large populations without excessive coordination with the participating units. Some military surveys are so extensive as to be very demanding on operating forces with precious little time to spend supporting such external demands. Although web-based surveys are currently popular due to the ease with which they can be administered and scored, this survey is a particularly poor choice to be administered via electronic means. A large canvassing of different populations could be used in several ways. First, natural groupings of responses could be used to classify persons of high, moderate, and low technology experience, and such ratings could be used as independent variables in future studies. The population sizes in the case study were too low to adequately break down groups in this manner. Then, the actual technology experience of groups of interest to military technology developers could be quantified. Rather than assuming the likely users are of the "Nintendo generation," a device targeted at Army Ranger team leaders could be designed from the start with actual data about the technology experience of those users.

Baseline performance metrics of standard tactical tasks. The tactical tasks used in this study, or other relevant tasks, could be measured in larger populations to establish baseline performance metrics such as task time and error rate.

Performance differences between populations of interest. In this study, students at the Defense Language Institute were used as surrogates for the real users of interest. Naval Postgraduate School students were not used under the untested assumption that their technology experience greatly

surpasses that of common military users. This laboratory could be used to definitively establish the performance differences between populations such as typical Marine infantrymen, DLI students, and civilian software programmers. This information could be used by developers, testers, and program managers to establish (or question) the external validity of studies that use test personnel from outside the actual populations receiving the equipment.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

With the Applied Warfighter Ergonomics Center, the Department of Defense now has an independent, organic capability to perform individual equipment usability testing, rather than relying on defense contractors and ad hoc testing. Military individual equipment can be scientifically evaluated under controlled conditions in the laboratory and realistic conditions in the field

Innovations, such as RPDAs, that demonstrably improve productivity, are useless if they are not adopted by warfighters in the field. More extensive research may find tradeoffs or reinforcement between the factors that motivate adoption and the factors that drive usability. Increasing user satisfaction, even in ways that limit the functionality of the equipment, may result in more widespread adoption and ultimately a better fighting force. Feature-laden devices that frustrate or confuse users, and are not adopted, will be just dead weight in the bottom of a pack.

This research introduces a validated, generalizable way of measuring what equipment works best for specific populations of users, and what equipment those users are most satisfied with. Both equipment and training can be designed so that functionality is accessible to the actual users (not just to the engineer on the next bench), and so that users will be inclined to fully utilize the equipment of their own volition.

B. RECOMMENDATIONS

The Applied Warfighter Ergonomics Observation Laboratory is primarily equipped for collecting measurements and establishing quantitative comparisons on individual military equipment. Nothing in the laboratory inherently lends itself directly to *creating* better designs, although it can (and should) be integrated into the early design, prototyping, and subsequent testing of many different types of equipment. Early user assessment, continuous testing and feedback, and in-

progress validation are key capabilities that this laboratory enables for military individual equipment. Appropriate program offices should be made aware of the laboratory's capabilities so that ultimately, individual soldiers, sailors, and Marines can benefit at a personal level from improved equipment made possible by the AWE Center.

The equipment in the laboratory is complicated and experienced users are required for the laboratory's continued operation and maintenance. A concerted effort will be required to maintain continuity in student skills with the laboratory equipment. Incorporating various parts of the lab's capabilities into existing and future courses will stimulate interest and increase the pool of capable users.

As shown by Carpenter and Nakamoto (1994), the behavior of novice users and early adopters may not be indicative of mainstream behavior. Users will tend to adapt their preferences towards the technology as it becomes adopted. So, the preferences of the first users may not be a good gauge of either qualitative satisfaction or quantitative performance. Task times and error rates observed early in Jordan's (1998) learning curve are of less interest than measurements taken of more experienced users. More experienced users will be more representative of how the equipment will actually be used in combat. A concerted effort, involving command interest at the highest possible levels, must be made to commit appropriately representative users to usability testing in this laboratory.

C. FOLLOW-ON RESEARCH

The field capabilities of the laboratory have been tested in small studies at Camp Roberts and in mobile data collection on the NPS campus. A full exercise of the behavioral observation capabilities in an actual deployed environment has not been performed. A full demonstration of this deployable capability, to validate the results of a laboratory study, would complete the establishment of this laboratory as a premiere center for research in military individual equipment.

The AWE lab is also potentially a source of justifiable human performance data for computer models and combat simulations, providing not just point estimates, but empirically derived distributions. The lab can be used to accurately measure task times, error rates, and training effectiveness in a wide variety of military applications.

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APPENDIX A.   GLOSSARY AND ACRONYMS

Some terms have a unique meaning within a specific context, such as within the Noldus Observer software. In those cases, the context is indicated in [brackets].

1:50,000	The scale of standard military maps used by ground forces. Such a map might be called a "one to fifty".
AWE	Applied Warfighter Ergonomics
BDUs	Battle dress uniforms worn by United States Army personnel.
Bearing	Direction from one point on a map to another point. Bearing may be given in relation to magnetic north (as read on a compass) or true north (as read from a map).
Behaviors [Noldus Observer Software]	Events that are recorded during a scenario are called behaviors. There are event behaviors, which occur at a single instant in time, and state behaviors, which have a duration. Behaviors are grouped into Behavioral Classes.
Cammies	Camouflage utility uniforms worn by United States Marines.
CDR	Combat Decision Range
Communications Check (Comm Check)	An initial exchange used to verify that communications gear is functioning. Users on each end will send and respond with a message.

Configuration [Noldus Observer Software]	A configuration should not be changed after starting to collect data. A configuration is locked after data files are made. If you unlock the configuration, you must remove the data files, make changes to the configuration, and then add the data files back.
DV	Dependent variable. Measurable data that can be predicted by the independent variables (IVs).
Grid, Grid Coordinate	The standard ground combat military method to identify points on a map (as opposed to latitude and longitude, used in aircraft and ship navigation). A four-digit grid coordinate (or just "grid") is accurate to within 1,000 meters. A six-digit grid is accurate to within 100 meters. An eight-digit grid is accurate to within 10 meters, and is the practical limit of accuracy in most current navigation devices, such as reading a 1:50,000 scale military topographical map.
HCI	Human-Computer Interaction
HF	Human Factors
HSI	Human Systems Integration
IV	Independent Variables (IVs) represent specific information about the participants and the scenario in any particular observation session..
IRB	Institutional Review Board
ISO	International Organization for Standards (acronym in French)

Leg	A single path from one point on a map to another point, often part of a *route*
MEF	Marine Expeditionary Force
Military individual equipment	Equipment that is normally carried and employed by a single person in combat
ORD	Operational Requirements Document
PDA	Personal Digital Assistant (handheld computer)
Patrol Route	see *Route*
Projects [Noldus Observer Software]	A project file contains the configuration, all observation and data files, and analysis for a given experiment. You can only do analysis on data within the same project.
Range	Straight-line distance from one point on a map to another point.
Route	A series of connected straight lines (legs) used to navigate from one point to a final destination, usually through several intermediate points.
RPDA	Ruggedized Personal Digital Assistant. A handheld computer that is designed for outdoor use in a variety of environments. RPDAs are commonly based on conventional Personal Digital Assistants (PDAs) running Palm OS, Microsoft Windows Mobile Edition (also called Windows CE or PocketPC), standard Microsoft Windows, or Linux.
Scoring or Coding	The process of turning observed behaviors into a data file for later analysis.

Subjects [Noldus Observer Software]	The roles ("billets" or "actors") played by the people simultaneously participating in an observation session, such as "Team Leader" and "Rifleman". Very often there will be only a single subject (the person using the equipment being tested), and so subjects will not be set up in Observer.
TNT	Tactical Network Topology. An ongoing NPS research project, formerly known as "STAN"
UI	User Interface
VOIP	Voice over Internet Protocol. A means to send digitized audio over networks using Internet Protocol (IP). VOIP has the advantage of using common networks, but is inefficient compared to other ways of sending digital audio.
Workspace [Noldus Observer Software]	An Observer workspace is a way to organize what projects are visible. Use different workspaces for different researchers, or completely different research. The Observer system in the AWE center has a Sample Workspace, a workspace for Class Projects, and separate workspaces for theses and other research.

APPENDIX B.   APPLIED WARFIGHTER ERGONOMICS
USABILITY LAB BASIC USER GUIDE

**Applied Warfighter Ergonomics
Observation Laboratory
Basic User Guide**

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Introduction

The Naval Postgraduate School (NPS) Applied Warfighter Ergonomics (AWE) Center's Observation Laboratory provides a laboratory and established methodologies for scientifically evaluating the human factors considerations of combat equipment used by military personnel under both controlled and realistic field conditions.

This User's Guide provides detailed, step-by-step instructions and a tutorial for using the laboratory in a basic configuration suitable for learning the system and for conducting a small study.

Capabilities

Technical capabilities of the Observation Laboratory include:

Capturing behavior in the laboratory using digital remote video cameras and fixed and wireless microphones.

Recording professional quality digital video in a laboratory or field environment to computer files and DVDs, using portable miniDV camcorders, or mobile device camera with portable miniDV VCR.

Mixing and recording audio and video from up to four sources (such as video cameras or video tape) onto AVI / MPEG-2 computer files, DVD, or videotape.

Producing highlight videos of events of interest.

Editing, producing, and analyzing observations using Noldus Observer software to score observation sessions and perform statistical analysis.

Direct screen-capture of the participant's computer screen to the observer's screen and to video.

Coding behavior and other events to time-stamped logs that are tied to the video files. Directly perform statistical analysis on the logs and jump to coded events on video.

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Research capabilities include:

Observe participant(s) while using a computer or other equipment in the lab.

Record comments during an after-action report (AAR) de-brief.

Record interviews and focus group studies.

Record participants reactions to projected video, or to scenarios read over loudspeaker.

Perform reliability analysis between coders.

Perform lag-sequential analysis on behaviors and events.

Examples of possible results

"When given the task, *'locate yourself on the [computer] map'*, 7 out of 16 participants (44%) performed it correctly within the allotted 60 seconds *(mean time to complete = 45.7s, σ = 9.8s)*, 5 participants (31%) completed the task after making one or more errors *(μ = 88.3 s, σ = 15.2 s)*, and 4 participants (25%) did not complete the task within 5 minutes *(gave up or experienced a technical malfunction).*"

"Buttons 1 and 2 were pressed correctly on the first try 98% of the time, button 3 was pressed correctly on the first try 87% of the time, but button 4 was pressed correctly on the first try only 45% of the time. Errors on button 4 included missing the button (28% of the time), pressing the wrong button (18% of the time), and dropping the device (9% of the time)."

"During the After Action Report (AAR) de-brief, team member #3 appeared to scowl or otherwise disagree with the team leader's comments on 6 occasions, but made no verbal comment. Members 1, 2, and 6 consistently reinforced each other's comments verbally and non-verbally."

"The equipment load as worn interfered with the participants' ability to shoulder their weapons. It increased the time to move from a standing position to a covered, kneeling firing position by an average of 3.2 seconds *(n= 21 subjects, average of 5 trials per subject, p=0.043)*. Here are some example video clips of the movement with and without the carrying load, showing how it interfered."

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How to use this manual

This manual is designed to allow a beginning student researcher to perform a basic usability analysis in the AWE Usability Lab. The equipment and procedures can be technically challenging at first, although you should be able to fully complete the tutorial (including recording and analyzing a test case) within three hours. It is imperative that you run through at least one test recording before trying to conduct even a small research study.

1. Before designing your experiment, read *The basics of observational research*.

2. When ready to conduct your usability testing, follow the step-by-step tutorials in *Preparation before an observation session* and *Recording a session (Laboratory)*. In these steps, you will create video files of your participants. You should also refer to *Appendix C: Observation Lab Technical Reference*. Appendix C details how to avoid or recover from the common problems you will encounter.

3. To analyze your video files, follow the step-by-step tutorials in *Scoring a Session* and *Analyzing Data*.

The other sections of this manual will be useful in configuring and upgrading the lab, and in guiding you in pursuit of more sophisticated use of the facility

The basics of observational research

To use the AWE Center Observation Lab effectively, researchers should prepare the following:

1. A well-formed research question to investigate.

2. A list of the independent variables (IVs) that will be controlled in each observation session. This may include information about the participant (name, rank, gender, etc.) and information about the scenario or environment ("wearing equipment load A", "night conditions", etc.)

3. A list of tasks to be given to the participant (e.g. "send a message")

4. A detailed list of "behaviors" (or "events") that will be observed and recorded. Virtually all possible behaviors of interest should be defined before hand ("start task", "press button 1","user commits error"..., "complete task") Not all events will necessarily occur, and some may occur multiple times.

5. A detailed, scripted scenario, including:

- A timeline.
- A description of what each researcher and participant will be doing at each point in the scenario.

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- Indications of what will trigger each event or behavior of interest (e.g. how does the participant know to start a task?).
- What equipment will be used (i.e. helmet, rifle, handheld device, etc.).

6. Any required paperwork such as IRBs, consent forms, background questionnaires, etc.

Recommended introductions to usability testing include:

Rubin, J. (1994). *Handbook of usability testing: How to plan, design, and conduct effective tests.* New York: Wiley.

Jordan, P.W. (1998). *An introduction to usability.* Bristol, PA: Taylor & Francis, Inc.

Perlman, G. (2005). *HCI bibliography: Human-computer interaction / user interface usability.* Retrieved August 2005, 2005 from http://www.hcibib.org/

Researchers will produce video files of the observation session for each participant, and then use Noldus Observer to score the behaviors observed. The data can be exported as Excel files, and analyzed however you please.

Different researchers can score the same sessions from video files, and automatically do reliability analysis between the coders.

The main phases of using the observation laboratory are to:

1. Setup the experiment

2. Record the session to video

3. Score the behaviors observed during the session

4. Analyze the data.

Practice runs before actually attempting to collect data should be considered absolutely necessary.

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Preparation before an observation session

For troubleshooting information, pictures, diagrams, and further details about each piece of equipment, see *Appendix C: Observation Lab Technical Reference*.

1. General

1.1. Reserve the AWE Observation Lab well in advance.

1.2. Confirm the date and time with all participants and others involved.

1.3. Open HSIL main room (GL-221, phone 656-3138), participant (GL-221a), and observer (GL-216, phone 656-3134) rooms

    1.3.1. Check lighting and inspect area for cleanliness and safety issues

    1.3.2. Secure any equipment, papers, etc. that could interfere with your session or confuse participants.

    1.3.3. Put up "RECORDING IN PROGRESS" signs and inform others in the area of your work.

1.4. Review the script or run profile(s) for the observation(s) to be made.

1.5. Brief participant(s) on cameras, microphones and general lab procedures.

1.6. Ensure consent forms are properly filled out and on file.

2. Set up participant room (GL-221a)

2.1. Arrange furniture in accordance with script. Pay attention to camera locations and try to keep the participants' normal movements from blocking the cameras. Tape marks on the floor to indicate where participants should stand.

2.2. Have an assistant stand on the marked spot while you preset the camera positions.

2.3. Provide paper, pencils, and other props (as required)

2.4. If used, turn on computer (power strip, CPU, display)

2.5. Participant workstation operations check (as applicable)

    2.5.1. Log on as local user.

    2.5.2. Check hardware and software configuration(s) and network connectivity.

    2.5.3. Log off, or otherwise prepare workstation for participant use.

3. Set up observer room (GL-216)

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3.1. Have script, notepad, and pens available for taking notes during the session.

3.2. Turn on power: three surge protectors, power button on computer.

3.3. Visually check power lights: surge protectors, computer, computer speakers, printer, event logging keyboard, two amps, VCR, two monitors, camera controller, and video mixer.

3.4. Log on to the Observer workstation as **Noldus Observer** (no password required).

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Recording a Session (Laboratory)
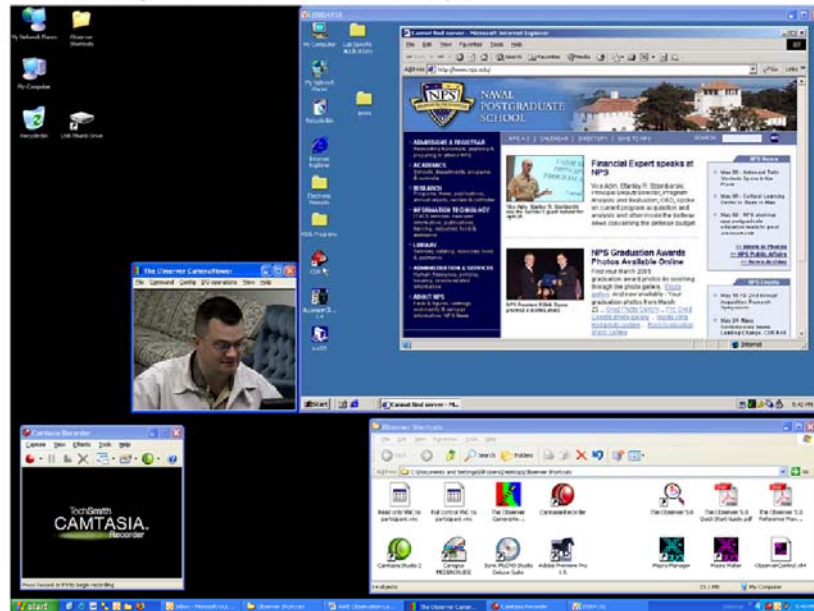
The instructions starting on the next page enable you to record the screen of the computer workstation in the Participant room, the live video feeds from the cameras in that room, and the audio from the fixed ceiling microphone and the wireless microphone.

If you are *not* using the participant computer workstation (for example, when doing a study on handheld devices), then:

- Skip step 1 below.

- In step 3, set the Observer CameraViewer window to 1/1 size instead of 1/2 size (see Appendix C: Observation Lab Technical Reference for instructions)

- In step 4.2.4, select only a region around the CameraViewer window using Camtasia Recorder.

For troubleshooting tips about each piece of equipment and software, see *Appendix C: Observation Lab Technical Reference*.

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1. **Set up view of participant workstation screen** *(only if using the participant computer workstation).*

   1.1. Launch application: **Read only VNC to participant**.

   1.2. Verify that you see the screen of the participant computer in the VNC window. The VNC window should be positioned in the upper right hand corner of the screen.

2. **Set up video cameras in Participant room.**

   2.1. This is one of the more complicated steps. See *Appendix C: Observation Lab Technical Reference* on the camera controller, and the video mixer for troubleshooting and details on other video setups.

   2.2. Use the camera controller to line up the two cameras at the participant station as desired. You should be able to see their output on the PREVIEW video monitor.

   2.3. Use video mixer to set up your video feeds.

      2.3.1. Raise the T-Bar to the top position and center the joystick.

      2.3.2. Tap the "CUT SOURCE" button (A – front camera, B – side camera) to select your camera.

   2.4. Verify that your desired video effects are displayed on the PROGRAM video monitor, and in the CameraViewer window in the next step.

3. **Display video feed from participant room on Observer computer screen.**

   3.1. Launch **The Observer CameraViewer (Picolo)**

   3.2. Check **Command>Live** to start the video feed.

   3.3. Position the CameraViewer window in the corner of the VNC window ("picture-in-picture" style), or to the left of the VNC window (if it is important not to block any of the user's screen).

4. **Set up video / screen recording software**

   4.1. Launch **Camtasia Recorder**

   4.2. Initial Setup of Camtasia Recorder – you should always record a brief (5-10 second) test video to verify your audio (sound check) and video configuration. (skip to step 4.3 for subsequent observations)

      4.2.1. Position the Camtasia Recorder window below and to the left of the other windows (completely out of the way)

      4.2.2. (optional) Verify configuration in **Tools > Options** (see the *Appendix C: Observation Lab Technical Reference* section)

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4.2.3. **Capture > Wizard**, choose **Region of the Screen**, check **Record Audio**, click **Next.**

4.2.4. Click the **Select Region** button, and click and drag from the upper right corner of the screen down and left, so that both the VNC window and the CameraViewer window are in the capture region. Click **Next.**

4.2.5. **Audio device** should be set to **SoundMAX Digital Audio**, (or other built-in sound card), and **Audio Input Source** to **Line In**. **Input Level** should be at maximum. Click **Next**.

4.2.6. Check the **Disable display acceleration box**, check **After save, play the video**, and *un*check **After save, edit the video**. Click **Finish**.

4.3. Record the session using **Camtasia Recorder**

4.3.1. Click the *Record* icon   ⬤ (or press F9) to start recording.

4.3.2. Click the *Pause* icon   ❚❚ (or press F9) to pause the recording.

4.3.3. Click the *Stop* icon   ◼ (or press F10) to complete the recording.

Be careful: clicking the *Delete* icon ✖ will completely delete your recording session!

4.3.4. Save the video file (with a detailed, descriptive name) in a specific folder for your project. Note that to play the video, you must have the DivX codec installed (available on the desktop of the Observer computer, or at: www.divx.com)

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Recording a Session (Field)

See Appendix D: Portable Observation Laboratory Embarkation List for a detailed list of the equipment that comprises the portable configuration.

Digital camcorders (handheld or tripod mounted) and digital voice recorders are used to record video and interviews. Firewire and USB connections are used to transfer video and audio files to the computer.

Noldus Observer may be fully used on the laptop only if the USB HASP key is attached.

In all other respects, the process of recording a session in the field is similar to that in the laboratory.

Some notes:

Take copious notes about what was recorded on each video tape and audio recorder, and exactly when. Each time a video tape is started or stopped, the time and a brief explanation should be recorded on the tape.

It can be painstakingly difficult to synchronize multiple simultaneous camera angles of the same event after the fact (for example, to set up a picture-in-picture shot, which would require editing with Adobe Premiere Pro).

It is much easier to practice a session once (or several times) before recording, and get the video shoot right the first time, than to do a lot of editing the video later.

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Scoring a Session

"Scoring" or "coding" is the process of turning an observation session (usually a video file) into a data file of events, event times, and (optionally) comments. In traditional usability testing, this may be done with stopwatches and logbooks, which is tedious and prone to error.

The Observer 5.0 software, by Noldus Information Technology of the Netherlands, will be used to assist in coding the observations and analyzing the results. Observer is capable of a great deal of customization to deal with different types of research (such as time-lapse recording of animals), different hardware (such as "old-fashioned" video tape time-code generators), and individual preferences. In this guide, we will present many settings (without further explanation) that are either specific to the NPS AWE Center, or are the simplest for the research conducted here. Advanced users should read Appendix A: Advanced Capabilities to learn about more sophisticated configurations, and about the simplifications used for this basic procedure.

Full details are available in the Noldus *The Observer* manual. The built-in help files in *The Observer* are easily readable, contextually appropriate, and highly recommended. Noldus offers telephone and e-mail technical support that has also proved to be very helpful.

The Observer can be installed on multiple computers, but requires the presence of the USB HASP key to be fully operational. Without it, it will operate in a restricted mode that does not allow changes to configurations, or the use of video files.

Definitions

The step-by-step tutorial in this section has examples of each of these definitions.

Independent Variables	Independent Variables (IVs) represent specific information about the participants and the scenario in any particular observation session. If you don't use IVs, and store all your participant / scenario information elsewhere, you lose a lot of analysis capability built-in to Observer.

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Behaviors

Events that are recorded during a scenario are called *behaviors*. There are *event behaviors*, which occur at a single instant in time, and *state behaviors*, which have a duration (see Appendix A: Advanced Capabilities, for more details). Behaviors are grouped into *Behavioral Classes.*

Subjects

The roles ("billets" or "actors") played by the people simultaneously participating in an observation session, such as "Team Leader" and "Rifleman". Very often there will be only a single subject (the person using the equipment being tested), and so subjects will *not* be set up in Observer.

Scoring or Coding

The process of turning observed behaviors into a data file for later analysis.

Projects

A project file contains the configuration, all observation and data files, and analysis for a given experiment. You can only do analysis on data within the same project.

Workspace

An Observer workspace is a way to organize what projects are visible. Use different workspaces for different researchers, or completely different research. The *Observer* system in the AWE center has a Sample Workspace, a workspace for Class Projects, and separate workspaces for theses and other research.

Configuration

A configuration should not be changed after starting to collect data. A configuration is locked after data files are made. If you unlock the configuration, you must remove the data files, make changes to the configuration, and then add the data files back.

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Noldus Observer step-by-step tutorial

1. Configure The Observer

See chapters 4 and 5 of The Observer Reference Manual. We will build a configuration that ends up looking something like this:
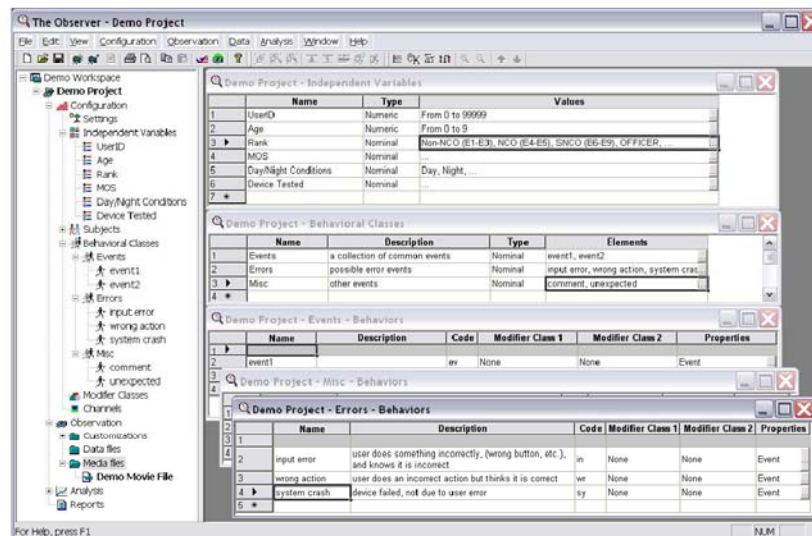
You will only need to do this long configuration process once for your project. You should plan on not making changes to the configuration after you have started collecting data. It's possible, but likely to cause problems.

1.1. Close other applications and launch the application: **The Observer 5.0**

1.2. **File>New Workspace** (if a new workspace will be used) or **File>Open Workspace**. **File>Workspace>Properties** will give you some information, and allow you to change the name of the workspace.

1.3. **File>New Project**. Enter a descriptive file name and a detailed description. Click **[Save]**.

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1.4. **Configuration>Settings**. Set as shown below:
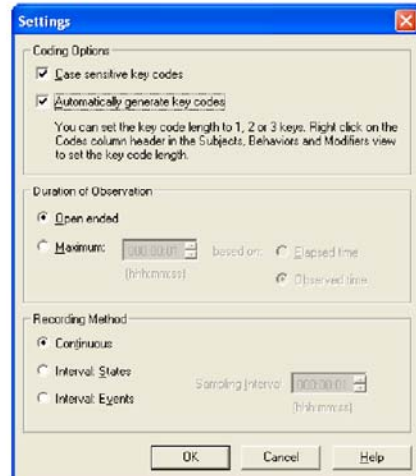
1.5. Configuration>Independent Variables. Adjust the window and the column sizes so that you can see all the columns. Enter information relevant to the specific observation session. This information will be used later in data analysis. Set the Type to Numeric or Nominal, as appropriate. The "more info" button with three little dots ⊡ in the Values column can be used to restrict the entry to specific values, to prevent errors (such as spelling) later on. At the very least, you will usually have an Independent Variable (IV) to identify the specific participant being observed, and an IV to identify the researching scoring the session. Having too many IVs can be slightly tedious to enter, but will cause no other problems. During later analysis, you may regret having recorded too *few* IVs.

	Name	Type	Values
1	ParticipantID	Numeric	From 0 to 99999
2	Scored by	Nominal	Takagi, Miller, ...
3	Age	Numeric	From 0 to 100
4	Rank	Nominal	Non-NCO (E1-E3), NCO (E4-E6), SNC(
5	MOS	Nominal	...
6	Day/Night Condition	Nominal	Day, Night, ...
7	Device Tested	Nominal	...
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1.6. **Configuration>Behavioral Classes.** (Adjust the window as necessary)

1.6.1. *The Observer* calls any event that you observe a *Behavior*. Behaviors are grouped logically into similar **Behavioral Classes**. Enter your

Behavioral Classes as shown below.

1.6.2. Enter **Behaviors** as elements within each **Behavioral Class.** Clicking on the more info button [ ] in the **Elements** column allows you to enter the **Behaviors** in each class.

Leave **Modifier Classes** set to **None**.

Always allow The *Observer* to set the behavior code for you.

<mark>Change **Properties** to **Event** for instantaneous events, such as error behaviors. This step is easy to miss!</mark>

1.6.3. **You should use State Behaviors for scoring events that have a specified duration, such as time to complete a task. The participant must always be in one of the states in every state behavior, such as: ON Task 1, OFF Task 1. This is easier to work with than separate events like START Task 1, END Task 1, because The Observer will automatically calculate the duration you are in a task, error condition, etc.**

1.7. **Configuration>Check Configuration.** The Observer will check your configuration for completeness and conflicts.

1.8. **Configuration>Review Configuration. File> Print.** Print a copy of your configuration for use during scoring.

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2. Start an observation session

We will set up for an observation session (from a media file recorded earlier) that looks something like this:
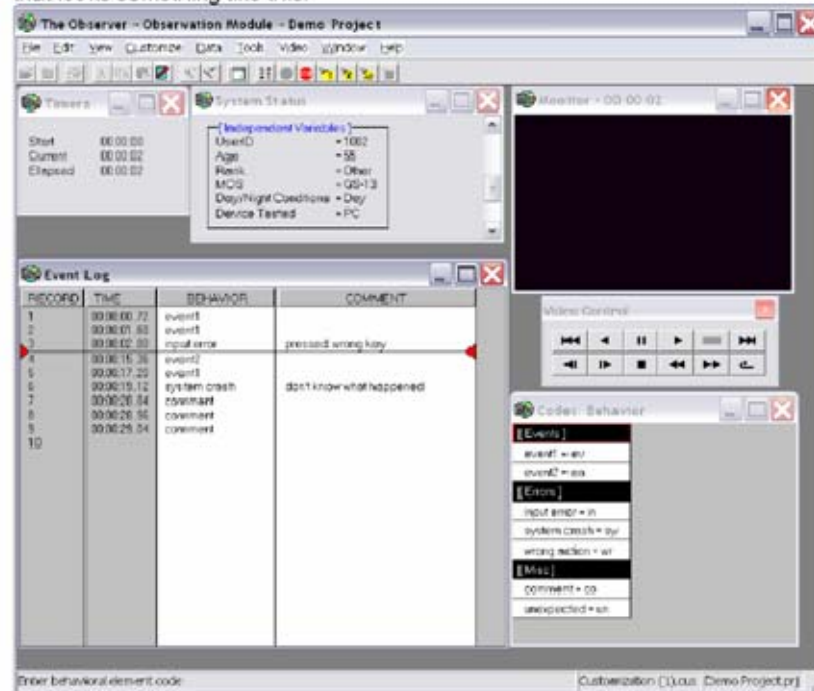
2.1. Launch and configure the Observation Module: Observation> Start Observing. You will only need to do this long configuration process once for your project. Scoring the videos will proceed much more quickly after the first time.

    2.1.1. If you think the Observation Module settings are incorrect for some reason, you can use Customize>Reset Customization (to set everything to the defaults) before setting the customizations below. The Help button in each of the following windows has excellent descriptions of these settings.

    2.1.2. View>Codes, Monitor, Timers, and Video Control should be checked, others are optional. (Monitor and Video Control may not be available until Timing is set in step 2.1.4). View>System Status can

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be useful to display Independent Variables or other information, as shown in the screen shot above.

2.1.3. Arrange and size the windows conveniently, as shown above.

2.1.4. **Customize>Timing**. Set as shown below. You should always use the same **Timing** settings for all observations.
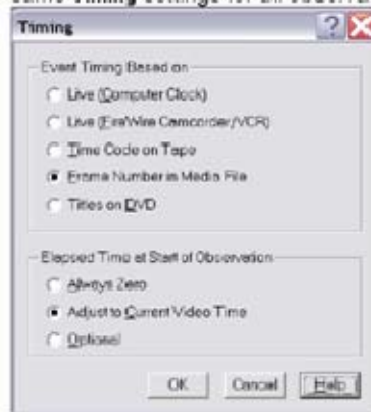
If set to "Live," you will be unable to change video settings in later steps, or load media files.

If set to "Always Zero," at the Start of Observation, you can have problems with time codes if you start in the middle of a video, and then rewind it past "zero."

2.1.5. **Customize>Operation**. Set as shown below:

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2.1.6. Customize>Window Properties>Codes. Set as shown below:
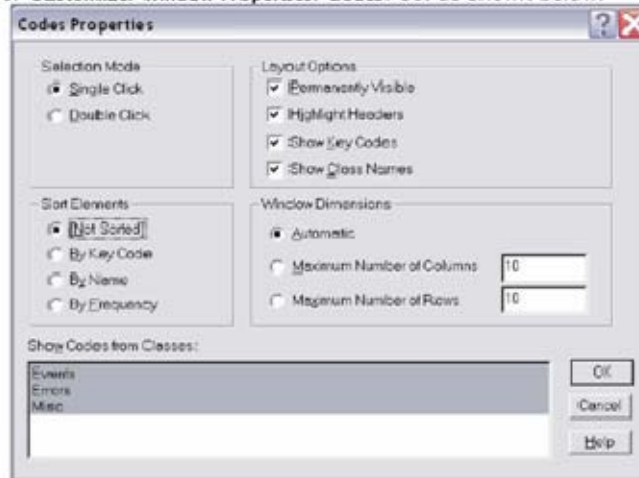
2.1.7. Customize>Window Properties>Event Log. Set as shown below:

"Video Time" option only applies to using analog video tapes
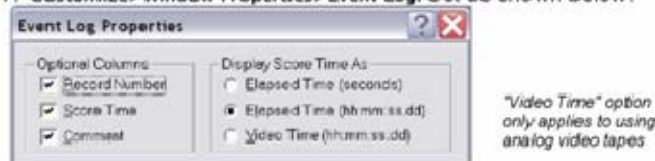
2.1.8. Customize>Window Properties>Timers. Set as shown below:

2.1.9. Customize>Window Properties>Video Control. Set to EXPANDED.

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2.2. **Customize>Data Storage**. Set as shown below:
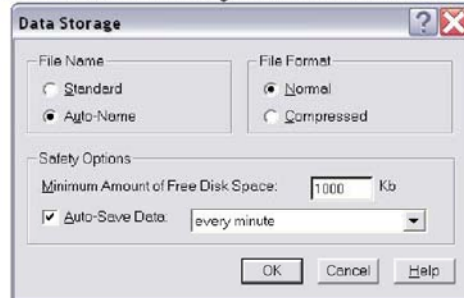
2.3. **File>Open>Media File.** If this is unavailable, check the **Timing** setting in step 2.1.4

2.4. **Data>Start Observation.** You will start an observation to score each separate observation (that is, a recorded video). The Observer will automatically supply a name (because of the Auto-Name setting in **Customize>Data Storage**). A **Title** allows you to enter a more detailed description.
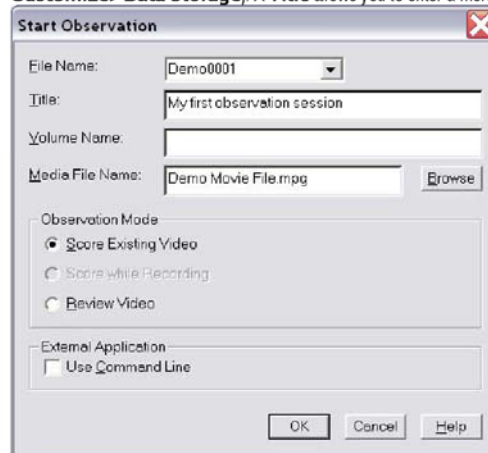
2.5. **Independent Variables**. Enter the values of the IVs for this session.

2.6. Finally, clicking this **Start** button will start the observation session:

    2.6.1. As the video plays, score behaviors by clicking the appropriate box in the **Codes** window. Use the **Video Control** window to pause or rewind the video.

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2.6.2. To enter a comment, double-click in the **Comments** column of the **Event Log**. <mark>You must press [Enter] when done typing a comment.</mark>

2.6.3. To edit a scored event:

    2.6.3.1. Pause the video using the **Video Control** window.

    2.6.3.2. **Data>Edit Observation**, and edit the event log as necessary.

    2.6.3.3. **Data>** *uncheck* **Edit Observation** to return to scoring mode.

2.6.4. When scoring the video is complete, choose: **Data>End Observation**

2.7. To go back and edit an existing observation file after ending an observation, choose **Data>Start Observation** (as in step 2.4) and enter the name of the existing observation file (instead of a new file name). If prompted for "Media File Position", do *not* check "Use Time in Media Fiel as Start Time for Data File".

Continue starting the observation normally. You can add new events to the previous file, or go into Edit Observation mode to edit existing events.

2.8. After you have completed scoring all the videos, close the **Observation Module** and return to the Main Module: **File>Return to Main**. When prompted to **Save** the customization file, click **[OK]**. The customization saves your Observation Module settings, window arrangements, etc.

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Analyzing Data

You can analyze data collected using Noldus *The Observer* in two general ways: exporting raw observations into a dedicated statistics package such as SPSS, S-Plus, or Excel, or you can use *The Observer*'s built-in basic analysis tools. You can also then export that analysis to another program. For most data analysis, you will need to consult the documentation about the specific ways you want to organize and analyze your data.

Exporting data from The Observer

The Observer raw data files are normally found in the directory:

C:\Documents and Settings\All Users\Noldus\The Observer\Workspaces\ Projects*Your Project Name***\Data Files**

You should not move data files (or any other files) from their default locations. Data files have the **.odf** file extension (example: **Demo0001.odf**), but are normal text files. Copy the data files you want to another location (like a folder on your desktop), and rename them with a **.txt** extension. They now can be opened with Notepad, Word, etc. Do not edit or alter the original **.odf** files.

It is probably easier to use Observer for organizing the raw data and performing basic statistics (see the next section) before exporting it to another program.

Using The Observer's analysis tools

Data analysis in *The Observer* is a multi-step process. First, you select the data to analyze, and then you can view the data graphically (*Time-Event View*), or perform elementary statistics or reliability analysis on it.

1. Elementary Statistics.

To understand all the options in this function, try generating a number of different statistics sheets to see the differences.

1.1. From The Observer Main Module (not the Observation module – see step 2.2 above): **Analysis > Elementary Statistics > Open Analysis Profile...** This will edit the current Statistics Profile, which defines what statistics will be computed, and how the output will look. You can create New Analysis Profiles and save different settings in each. **<Use active Data Profile>** is fine for the first use. If you don't already have one, *The Observer* will create a generic data profile for you that includes all the data collected (usually

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what you want).
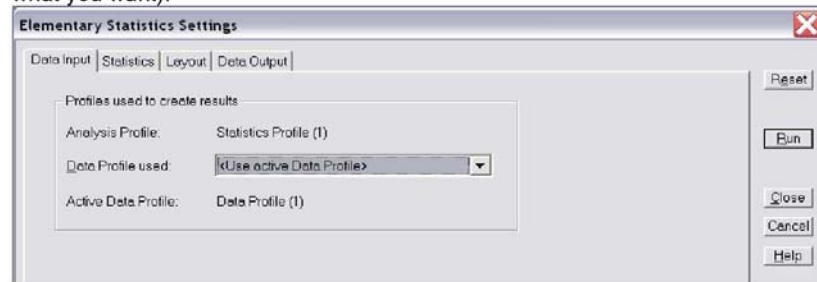
1.2. On the **Statistics** tab, choose the statistics you are interested in. Durations will only apply if you have used state behaviors or have defined time intervals between certain events.
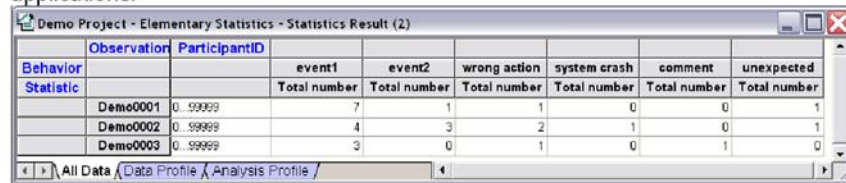
1.3. On the **Layout** tab, turn off the **Modifiers** and the **Subject**, since you will normally not use either.
Use the up/down and left/right arrows to change the arrangement of rows and columns on the output statistics. You should probably run some different layouts to figure out how you want the Statistics Results to look.

Turn on **Interval** only if you are using state behaviors, or have defined time intervals between certain events.

Turn on any **Independent Variable** values you would like to show on the Statistic Result output.

Change **Sheet Per** to <one sheet> to put all the data on a single sheet, instead of on separate tabs. Otherwise, choose how you want the tabs broken out.

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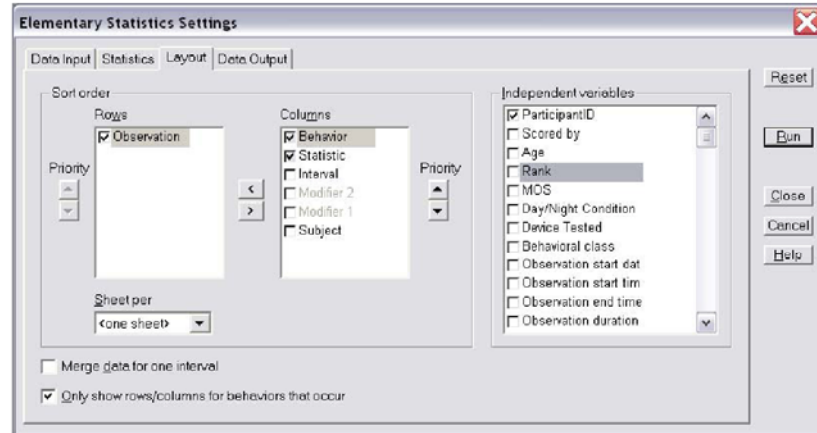
1.4. Click **Run** to create the **Statistics Result** from this Analysis Profile. Note that you can select cells (using **shift+click** to select multiple rows) in the Statistic Results output and paste them directly into Excel and other applications.

	Observation	ParticipantID						
Behavior			event1	event2	wrong action	system crash	comment	unexpected
Statistic			Total number	Total number	Total number	Total number	Total number	Total number
	Demo0001	0...99999	7	1	1	0	0	1
	Demo0002	0...99999	4	3	2	1	0	1
	Demo0003	0...99999	3	0	1	0	1	0

All Data / Data Profile / Analysis Profile /

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2. Time-Event View. A Time-Event Profile is a quick way to look at data graphically, or to organize it to export to other software.
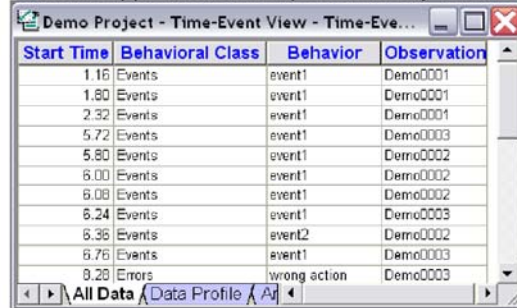
2.1. Use the Layout Tab to choose a **Time–Event Table** or **Time–Event Plot**. In the examples below, **Sheet per** is set to **<one sheet>** so that all data is shown on a single plot or table. Click **Run** to create the table or plot.
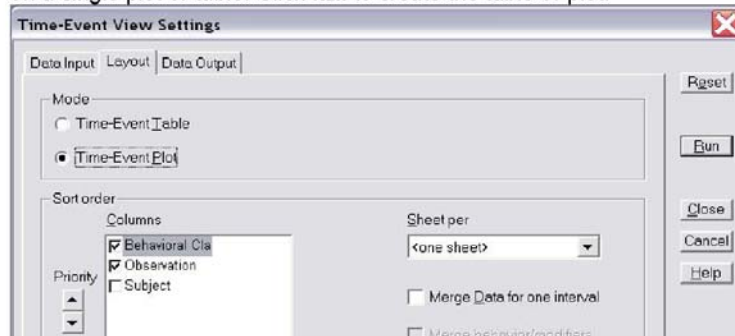
2.2. Sample **Time–Event Plot**. You may have to resize the window to see all the data.

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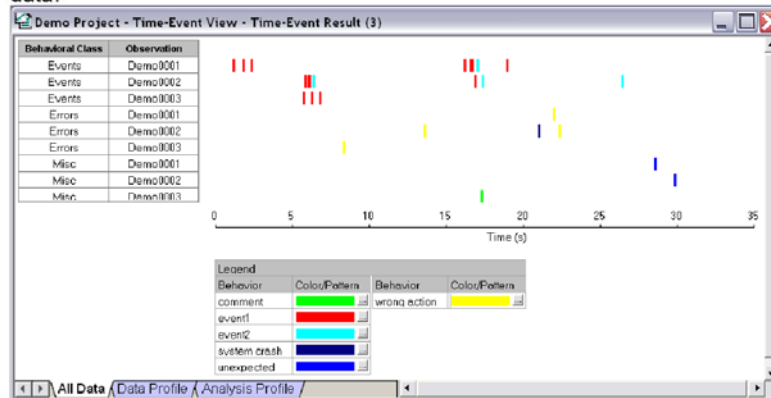
2.3. Sample **Time-Event Table**. This data can be cut and pasted into other Windows applications, or exported directly to .XLS or .CSV files.

Start Time	Behavioral Class	Behavior	Observation
1.16	Events	event1	Demo0001
1.80	Events	event1	Demo0001
2.32	Events	event1	Demo0001
5.72	Events	event1	Demo0003
5.80	Events	event1	Demo0002
6.00	Events	event1	Demo0002
6.08	Events	event1	Demo0002
6.24	Events	event1	Demo0003
6.36	Events	event2	Demo0002
6.76	Events	event1	Demo0003
8.28	Errors	wrong action	Demo0003

All Data / Data Profile / An

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3. Data Selection.

Use Data Profiles to restrict or filter your analysis to specific subsets of the data.

3.1. From *The Observer* Main Module (not the Observation module – see step 2.2 above): **Data > Data Profile > New...** Give the data profile a name. Note that a data profile window has items in rows, and six tabs along the bottom:

3.2. Edit a row on the appropriate tab to create the filter for your data.

3.3. Once you've created a filter for your data using a **Data Profile**, you can select that **Data Profile** in **Elementary Statistics**, **Time–Event Plot**, and other analysis functions.

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Video Equipment: Other Capabilities

The video equipment in the observation laboratory can be used for a variety of other functions, including:

- Capturing VHS video tapes to computer files or to DVD.

- Recording ("burning") computer media files onto DVDs that can be watched on standard home or computer DVD players.

- Recording training sessions from multiple video angles and direct screen capture to computer media files.

Capturing a VHS video tape to a computer file

1. Complete the standard system start-up

2. Put the videotape to be recorded from into the VCR. Rewind the tape to the starting position.

3. The output cables from the VCR go to 'video and audio input #4' on the Video Mixer. The audio output of the video mixer gets plugged directly into the Canopus board on the CPU. You will have to disconnect the current audio inputs in order to do this. Note what they were so you can put them back again when you are finished.

4. Set Video Mixer to input source D, which corresponds to input #4. If the video input is not displayed, see the Focus MX-4 mixer manual to check the video "Route" setting for input 4.

5. On the computer, launch the Canopus Media Cruise application.

6. Set the Canopus Media Cruise to video recorder mode.

7. Click "Format", and set it to "MPEG2" and "Program Stream".

8. Click "Parameter"; enable and enter the max video capture time (i.e. the playing time of the video tape.) You can stop the recording earlier, but it will run all night if you don't put in a time.

9. Click the folder icon on Canopus; this is also known as the "Capture File Configuration". Enter a file name and location.

10. Press Play on the VCR to preview the audio and video levels. When these are satisfactory, rewind the video to its starting position.

11. On the Canopus control panel on your computer screen, click the button with the red dot to begin recording, then immediately press play on the VCR.

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12. Click the button with the white square to stop the recording.

Burning video files to DVD

1. Launch Sonic My-DVD Studio Deluxe Suite.

2. Choose Video, then Create Project, then DVD.

3. Click the "Add files" button, then select the file that you want to burn onto a DVD.

4. Change the background and text as desired. This is the time to add subtitles, trim or crop, etc.

5. The quality setting should be set to "Fit to DVD".

6. Insert a recordable DVD into the computer. (Note: the CPU in the Observation room only works with 'DVD plus' discs, such as 'DVD +R' or 'DVD +RW'. It will not work with 'DVD dash' discs, such as 'DVD-R' or 'DVD-RW'.

7. To create the DVD, click on the big red "Burn" button.

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Appendix A. Observer: Advanced Capabilities

The following are the main restrictions that have been used in this Noldus *The Observer 5.0* configuration to simplify the tutorial in this guide:

- Only event behaviors – no state behaviors
- One *subject* only (and so, no *channels*)
- No modifiers
- No *live scoring* – scoring from video only
- No use of the event-logging keyboard
- Recording video using only Camtasia and CameraViewer, rather than the Canopus MPEG-2 encoder card.

The Observer is capable of much more sophisticated configurations. More in-depth research will benefit from using features such as:

State behaviors are useful for coding tasks in usability analysis. State behaviors have a *duration*, while event behaviors are single points in time. State behaviors in a behavior class (e.g. "posture") are mutually exclusive and must define all possibilities (such as: standing, sitting, prone, other). Every subject must be in some specific state behavior in each state behavior class at all times. Some usability researchers will use states to identify tasks being performed. Analysis on the duration of events is easier when using state behaviors than with event behaviors.
You can coerce two event behaviors to act like the beginning and end of a state behavior, to get data on duration, but it's easier to just use state behaviors.

Multiple *subjects*. Subjects are the roles played by the participants, such as "Primary User," and "Assistant". Subjects would *only* be used if there was more than one person simultaneously participating in a scenario.

Modifiers can be used to refine behaviors, such as a "walking" behavior, with modifiers like "slowly" and "quickly", rather than many separate individual behaviors, such as "walking quickly" and "walking slowly". Using modifiers allows for more options during analysis to group and categorize the data.

You can code behavior live while it is being recorded, and then go back to the video file and refine the coding later. This might save time for experienced coders doing a lot of observations, but is generally too much to do at once for beginners.

The *event-logging keyboard* can be customized to the specific events used, and labels attached to the keys. The jog-shuttle dial, used to control video clips, is extremely helpful. There is a "programming switch" on the upper right side of the X-Keys keyboard that should show red to program, black to use. You may have to exit other applications when programming the keyboard, and sometimes even restart the computer to get the macros to "stick".

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Event Summaries (Noldus *The Observer* Reference Manual section 8.4) can be helpful for generating quick reports.
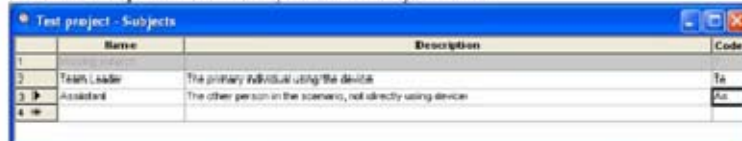
Reliability analysis – consistency between different coders, or a single coder scoring the same video.

Lag-sequential analysis – identifying events that tend to follow or precede other events, and even "chains" of events.

The Canopus MPEG-2 encoder card is a faster, higher-quality way to record video *if only video from the cameras is required*. The Canopus system (card and Mediacruise application) cannot record events on the screen, such as the VNC screen.

1. Configuration>Subjects

Subjects will only be used if there are multiple people interacting in a scenario at once. Subjects will often not be used. If there is only one subject, no configuration is necessary for subjects. If subjects are used, give them the name of the role, position, or billet they are performing in the scenario. If necessary, the individual participant's actual name should be stored as independent variables, not as the subject name.

	Name	Description	Code
1			
2	Team Leader	The primary individual using the device	Te
3 ▶	Assistant	The other person in the scenario, not directly using device	As
4			

Test project - Subjects

1.1. **Configuration>Channels**. Channels are required if there is more than one subject. In your scenario, subjects may be allowed to perform all defined behaviors, or, by limiting the available channels, subjects may be restricted to only specified behavior classes. This is mainly to prevent data input errors, and group subjects and behaviors more logically.

Topics to ignore in using Noldus *The Observer*

1. *Coding from videotape*. In the past, analog videotape recorders with "time-code generators" were used in behavioral research. Much of the video and timing configuration in *The Observer 5.0* deal with these situations, and should be ignored.

2. *Interval (states or events) recording*. Situations calling for these types of recording methods are uncommon. As opposed to *continuous recording* (which we use), these generally apply to time-lapse or long-term observations.

For more information on these capabilities, see the Noldus *The Observer 5.0* documentation. Also, Noldus has been very helpful in email and telephone tech support.

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Appendix B. Observer Lab Components

Observer station components

Observer workstation computer	Dell Dimension 8400 P4 3.2Ghz
	70GB HD, 1GB RAM, Philips DVD8601 CD-RW/DVD+RW, FireWire, ATI Radeon X300 Series 128MB
	with special hardware and software described below
Event logging keyboard	PI Engineering X-keys SE
Camera joystick control	Telemetrics CP-ITV-VC4
Video mixer	Focus Enhancements MX-4 S/N 050518, near San Jose; (408) 370-9963, support@focusinfo.com, manuals and firmware downloads at: http://www.focusinfo.com
miniDV VCR (portable)	Sony GV-D1000
Wireless microphone receiver	Azden 200R
Mobile device camera receiver	Kern Gigasystem RX German company
Observer microphone	Shure MX412D/C
Mic amp	ProSonus MP20
Speaker amp	US Audio whirlwind P-12
Speakers	Radio Shack 400-4101
B&W video monitors	Show the preview and program outputs of the video mixer
One-way mirrored glass	48" x 36"

Observer workstation (special hardware and software)

Noldus HASP USB serial key License number: OB050-05422-DGAA	Must be present to use Noldus Observer software
Noldus The Observer v5.0	Software application for coding and recording behavior
Canopus MPEG Pro MVR1000SX PCI card	Video encoder board - real-time MPEG-2 encoder (from analog or DV input). Takes the actual output of the video mixer. Canopus is in San Jose; (408) 954-4506, tutorials and support at: http://www.canopus.us
Canopus Mediacruise	Program to encode analog video input to MPEG-2 files
Canopus MVR DV-MPEG File	Used to convert raw DV files to MPEG-2 format

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Converter	
Euresys Picolo PCI card	Video capture board (PCI slot 2). Allows screen capture of the program output from the video mixer (the Canopus board does not).
Noldus CameraViewer	Viewer for preview video in to Picolo Card from video mixer
Sonic MyDVD Deluxe Suite 6.1	Software DVD player/recorder. Watch, edit, and burn DVDs (cannot use PowerDVD or WinDVD – they conflict with *The Observer*)
Techsmith Camtasia Studio 2.0.3	Record, edit, publish videos of PC desktop activity
RealVNC 4.0 (in viewer mode)	Observe / control the participant's computer screen
X-keys Macro Works	Controls the event logging keyboard
DivX codec 5.05, DivXplayer 2.6	Video codec and player for highly compressed DivX video files
Adobe Premier Pro 1.5	Professional video editing software

Participant station components

Participant workstation computer	Windows 2000, 512MB RAM, 2Ghz Pentium 4. Two 18 GB drives. Could be any computer, but must run RealVNC **Server** (which requires administrator access to install)
Pan / tilt / zoom cameras (2)	*Canon VC-C4 and Canon VC-C50i*
Ceiling microphone	*Shure MX200* omnidirectional
Wireless microphone	*Azden 31 LT* freq: A4 171.905 Mhz
Mobile device camera	*Noldus MDC-03N*
Office furniture	Desk, conference table, dry-erase white board, chairs
Individual military equipment	Helmet, flak jacket, MOLLE harness and cartridge belt, rubber M-16s

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Appendix C. Observation Lab Technical Reference

The most commonly referenced tips and troubleshooting facts are <mark>highlighted</mark>.

Observer Station

Observer workstation computer	Computer name: D2M6ZM51 (not on NPGS domain)	
	IP Address (Static):	131.120.147.112
	SNM:	255.255.252.0
	Gateway:	131.120.144.1
	DNS servers:	131.120.18.40
		131.120.18.41
	MAC Address:	00-11-11-3D-D2-22
	Dell Asset Tag:	2M6ZM51
	Administrator password:	NOLdus2M51
	normal username:	Noldus Observer
	password:	(none)
	Backed-up (Ghost image) by Jim Zhou, 656-2499, on 18 Feb 05. Image files stored on: \\stingray\ghostimages\ghost\desktops\dell\pcshop	

Camera joystick control	Reset by unplugging and plugging back in if one of the cameras is turned off, or other problems occur.
	First, press the button corresponding to the camera you want to control, then use the joystick, zoom, or focus controls. There is a brief delay before the camera will begin to move.
	Hold the set buttons down for 4 seconds to set presets (direction, focus, and zoom). Sometimes, you might want to turn the auto-focus OFF, so that it doesn't keep changing.

Video mixer Focus MX-4	There are always two video sources selected (with the two rows of buttons at the top of the mixer) – the "current" (or "cut") source, and the "next" source.
	Configuring video inputs
Controlling this mixer can be confusing. You will likely have to	If you change the input cabling at all (lab cameras, MDC, VCR, etc.), you must set them up by pressing the [ROUTE] button (ch 2 in manual). Note whether your inputs use the S-video or the RCA-style

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consult the full manual for any problems you experience.

You can only display two inputs simultaneously (even though there are four different inputs).

Useful effects include picture-in-picture (PIP), top-to-bottom, and side-by-side cuts.

By adjusting the cameras' zoom level and positions, and how you have a cut adjusted, you can arrange multiple views of the participant room pretty much however you want. For example, if you want to have two views of the participant next to a VNC window:

1. Set the Observer CameraViewer window to 1/1 size.

2. Use transition #9 (top-to-bottom), or a PIP window, to split the view between the cameras.

3. Hide the right half of the CameraViewer window behind the VNC window.

4. Adjust the cameras' zoom and pan to show the views of the participant that you want.

composite jacks.

Configuring Video outputs

Press the **[DISPLAY]** button multiple times to see different views of the camera selections on the **PREVIEW** monitor, which is used for configuration. The actual output to the computer is shown on the **PROGRAM** monitor.

Basic operation – always do this first!

Slide the T-Bar to the top position and center the joystick. Select your two inputs (current and next), by tapping one button in the top row of **SOURCES**, and one in the bottom row.

Side-by-side cut

Press the **TRANSITIONS – [BASIC]** button.

Press the right arrow to move the cursor to transition #7 (side-by-side cuts). Press OK.

Move the T-Bar up and down to run the transition. Adjust the cameras if simultaneous side-by side views are desired (with the T-Bar half-way).

Picture-in-picture (PIP)

The "next" source will be the small PIP window.

Press the **PIPs** button.

Use the T-Bar to size the PIP window.

Use the joystick to move the PIP window into position.

Press **[PLAY]** to start the PIP on the Program output.

Be careful not to bump the joystick or T-bar while recording!

To completely reset the mixer (including firmware) back to factory state: power on while holding down Shift and Setup (manual Ch13). You will may have to setup the input [ROUTE] again.

Load firmware upgrades via Ethernet:

IP Address: 131.120.147.111 (static)

SNM: 255.255.252.0

gateway: 131.120.144.1

	MAC Address: `00-02-ea-4c-47-e6` S/N: 050518 Check FOCUS website for firmware upgrades.
miniDV VCR (portable)	Can run off battery or A/C power. Needs special A/V input cable (3 RCA F to 1/8" plug). Can convert analog (RCA or S-Video) input to raw DV over firewire for capture to computer – useful with laptop, but the Canopus MPEG-2 encoding board is preferred when available (on desktop computer only).
Wireless microphone receiver	Power ON, check antenna Adjust volume as required
Mobile device camera receiver	Power ON, check antenna. Will suffer RF interference from wireless networking equipment.
Observer microphone	Push To Talk (PTT) – touch and hold to talk. Can change PTT function to "always on," or other settings, by setting DIP switches (see mic manual).
Mic amp PreSonus MP20	CH1: Ceiling mic in Participant room CH2: PTT mic in Observer room Both channels: **ON** (lit): Ø, +48V, 80Hz, L/R **OFF** (unlit): PAD GAIN: *as desired* IDS: max PAN: center Master Level: *as desired* Phones: *as desired* Adjust GAIN to control a mic's recorded volume.
Speaker amp	CH1: Ceiling speaker in Participant room CH2: Ceiling speaker in Observer room – note that this is completely separate from the *computer* speakers, which may (or may not) be playing the same audio.

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	headphones OFF (out), volume about 5 on ch 1 & 2
Observer/Participant room Speakers	Driven by amp (not self-powered). Ensure connections are good.
	Note that these are totally separate from the *computer* speakers.
Noldus *HASP* USB serial key License number: OB050-05422-DGAA 	Be very careful with it. This is very expensive to replace if lost. Do NOT update drivers for the Aladdin USB HASP, it can cause your USB hasp key (dongle), and Noldus software to stop working. To correct it: 1. Download the latest command-line HASP 4 drivers from http://www.aladdin.com/support/hasp/hasp4/enduser.asp and save them to a folder such as c:\temp 2. From the Windows Start menu, select Run and then type **cmd** (a command window will open) 3. Type **cd c:\temp** 4. Remove any hardware keys from your USB or LPT ports 5. Type **hinstall /r** (to remove existing HASP drivers) 6. Type **hinstall /i** (to install the new drivers) 7. Close the window and insert HASP key.
Noldus *The Observer* License number: OB050-05422-DGAA Registered users with Noldus: Barbara McKay, Koichi Takagi Updated to: v5.0.31 from www.noldus.com 	Sales and installation by: John J. McGraw, Sales Engineer, j.mcgraw@noldus.com Bart van Roekel, technical rep from the Netherlands, B.vanRoekel@Noldus.com Noldus Information Technology Inc. 751 Miller Drive Suite-E-5 Leesburg, VA 20175 Phone: 703-771-0440/800-355-9541 Fax: 703-771-0441 Noldus helpdesk, normal working hours Pacific Standard Time (PST): (866) 860-3580 Noldus Technical Support Knowledgebase:

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Noldus support request form:
http://www.noldus.com/site/doc200407095

Canopus *MPEG Pro MVR1000SX* PCI card	Internal PCI card – hardware MPEG-2 encoder/ decoder. Controlled by the Canopus MediaCruise application.
Canopus *Mediacruise*	Video recorder software for the Canopus card. Used to encode the program output of the video mixer (and the audio inputs connected directly to the card) to MPEG1 (smaller) or MPEG2 (recommended) files. This is the highest quality way to record video from the video cameras only. *If you need computer screen shots too, you must use Camtasia and the Picolo CameraViewer application for video input.* VideoCD quality (MPEG1, .MPG file extension) is about 10MB/min (1hr ≈ 650MB = 1 CD) DVD quality (MPEG2, .M2P file extension) is about 40MB/min (2 hr ≈ 4.8 GB = 1 DVD) The Mediacruise window bypasses the Windows operating system and cannot be captured with screen shots or Camtasia. Before recording, set the **FORMAT**: VCD MPEG1 for the smallest files, or DVD MPEG2 for higher quality. Before recording, set the **FILE** to record to (click folder icon). Can also be used to play MPEG-2 video. Uncompressed DV files from a camcorder (.AVI extension) use about 200 MB / min ≈ 13GB / hr
Canopus *MVR DV-MPEG File Converter*	Will convert a raw DV file (usually downloaded from a camcorder) to MPEG2 (or MPEG1). Takes almost real-time to process (a 30min file takes about 30min to convert).
Elecard 2.0	MPEG-2 video player application that works with Noldus Observer to play MPEG-2 video when scoring videos. Without this program, MPEG-2 playback in Noldus Observer has limited functionality.

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Euresys *Picolo* PCI card	Internal PCI card – turns analog video input into a digital stream. Does not encode to MPEG2, but, (unlike the Canopus card), the Picolo CameraViewer window can be screen captured by Camtasia, or the Windows operating system.

The Observer *CameraViewer* Video viewing application for the Picolo PCI card	Used to capture program output of the video mixer with Camtasia. The contents of this window can be captured by screen shots or Camtasia.

Check **Command > Live** to start video, uncheck **Command > Live** to make configuration changes.

Important settings:

Config > Input Configuration *(check this if video looks weird)*

If using Picolo S-Video input jack: S-Video via Mini Din 4 (or via DB9), S-Video 525 Lines

If using Picolo BNC input jack: Composite via BNC, Composite NTSC/EIA

Config > Scaling and Region of Interest: Click either 1/1 or 1/2 in both Horizontal and Vertical, then drag window to desired size.

View > Always On Top: As desired

View > Toolbar: Off

View > Status Bar: Off

Other settings (most should not need adjustments):

Config > Color Format: RGB24

Config > Adjustments: Restore default values. Adjust during video play (live) if desired.

Config > Filters and Settings: All OFF except: Full range ADC

Config > Acquisition Settings: Frame (fields are grabbed in any order)

I/O Operations: No settings should need to be changed in this menu.

I/O Operations > I/O Lines: 4 buttons on top checked.

	I/O Operations > Trigger Config: Rising edge
	I/O Operations > Arm-Acquisition: unchecked
	I/O Operations > Live-TriggerStop: unchecked
Sonic *MyDVD Studio Deluxe Suite*	Used to burn DVDs that are viewable in any DVD player, with simple menus, etc. Has a very simple video editor that can trim and combine clips and add titles, but not much else. Will "fit" (transcode) video files to the available size on the DVD disk. This is not the "LE" version that comes with the DVD burner, which can not do editing, resizing, etc.
Techsmith *Camtasia Recorder* 2.0.3	Used to capture (to .AVI video file) anything shown on the computer screen, including the contents of the CameraViewer window, but NOT including the Canopus Mediacruise window. Suggested settings: **View menu: Standard**, *un*check all toolbars **Effects>Annotation**: *un*check all options **Effects>Audio**: check Record Audio (only) **Effects>Cursor**: Show Cursor **Effects>Zoom & Pan**: *un*check all options **Tools>Options>AVI tab**: *un*check Auto Configure and Time-lapse capture. Set to 15.0 frames/sec Check: Interleave audio every 1 seconds. **Tools>Options>AVI tab > Video Setup: Compressor**: DivX codec, [OK] **Tools>Options>AVI tab > Audio Setup: Format:** use MPEG Layer-3 if available (for smaller file size), otherwise PCM. Attributes: 22 kHz (or more), Mono. (16-bit, if PCM), [OK] You might also check the Windows sound settings: **Start Menu>Control Panel>Sounds and Audio Devices>Audio Tab**, **Sound recording**: Default Device: (Sound card), **Volume**: ensure that "Line-In" is checked, volume to max. **Tools>Options>File** tab: check Ask for File Name **Tools>Options>File** tab: check After save, play the video, *uncheck After save, edit the video*.

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Techsmith *Camtasia Studio* 2.0.3	A simple video editing application that's good for quick trimming of clips, adding sound and voice annotation, for exporting to Flash, and especially for adding on-screen text and comments.
RealVNC 4.0 (**viewer** mode)	Connect to: `131.120.147.110` password: `noldus` Right-click title bar for options. Useful options: view only, scale
Event Logging Keyboard *P.I. Engineering X-keys SE* *PIE002-13 Jog & Shuttle Editor* 	Used to code events in Noldus Observer, ffwd/rewind through videos in Observer (use ObserverControl.xk4 file as a template), and for video editing
X-keys *Macro Works*	Sets up the event logging keyboard for use with different programs. The Noldus Observer basic control file, to use as template for other configurations, has settings stored for using the jog/shuttle dial, but none of the keys: `ObserverControl.xk4`
DivX codec and DivX player 	A highly compressed codec for AVI files that is popular for movies and video. Download free from: http://www.divx.com The codec must be installed on any computer that needs to play video files created with the Observer system.
Adobe *Premier Pro* 1.5 Note required updates: MainConcept MPEG encoding 1.1 Windows XP KB886716	High-end professional video editing program. Expensive and difficult to use. It can do multiple picture-in-picture and other features not found in cheaper video editing programs, but is not easy to use for simple projects. If you can take the time to learn it, it's the most powerful video editor available for Windows.

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Participant station

Room 221a	Combination: 3,1,5

Participant workstation computer	Computer Name: `IT004151` (on NPGS domain)
	IP address: `131.120.147.110` (static)
	SNM: `255.255.252.0`
	gateway: `131.120.144.1`
	DNS servers: `131.120.18.40`
	`131.120.18.41`
	MAC Address: `00-04-76-D7-72-EC`
	Administrator account: `admin`
	password: `HSILpa$$`
	Local user account: `participant`
	password: `HSIL221a`
	Windows 2000, 512MB RAM, 2Ghz Pentium 4. Two 18 GB drives.
VNC Server	Allows the participant computer to be viewed or controlled by the observer station. Setup VNC from the Admin account on the participant workstation.
Pan / tilt / zoom cameras (2)	Do not move cameras by hand – only by remote. Press <HOME> on remote if moved by hand (see manual)
Ceiling microphone	Powered by mic amp.
Wireless microphone	Check 9V battery, have spares on hand. Turn OFF after use.
Mobile device camera	Low battery will cause interference on video.
	Check 9V battery, have spares on hand.

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	Turn OFF after use.
	Can be used with cable, hard-wired directly to an RCA video input (for higher quality), or through the MDC wireless receiver.
Office furniture	Check arrangement in relation to cameras and microphone.

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System Hardware Components

One-way mirrored glass
Observer microphone
Observer workstation monitor, keyboard, mouse
Camera joystick control
Video mixer
Event logging keyboard

Program B/W monitor

Preview B/W monitor

Wireless mic receiver

Speaker and mic amps

Observer workstation computer

Printer

Camera joystick control   Video mixer

Workstation mouse Event logging
keyboard

Mobile Device Camera (MDC)
attached to a Ruggedized PDA

miniDV camcorder mounted on mini
tripod

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Wiring Diagram: VIDEO
AWE Center Observation Laboratory

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Wiring Diagram: AUDIO
AWE Center Observation Laboratory

Participant Room

Observer Room

CH 1 OUT   CH 2 OUT

CH 1 IN   CH 2 IN

CH 1 OUT   CH 2 OUT   MIX OUT L   MIX OUT R

CH 1 IN   CH 2 IN

R   L

CEILING MIC

OBSERVER PTT MICROPHONE

Audio out to speakers

Audio Line-in

USB HASP KEY

VGA Out   S-Video Out   DVI Out   Video Card

Audio Out   Audio In   S-Video In   CANOPUS card

R   L

split mono   R

L

WIRELESS MIC RECEIVER

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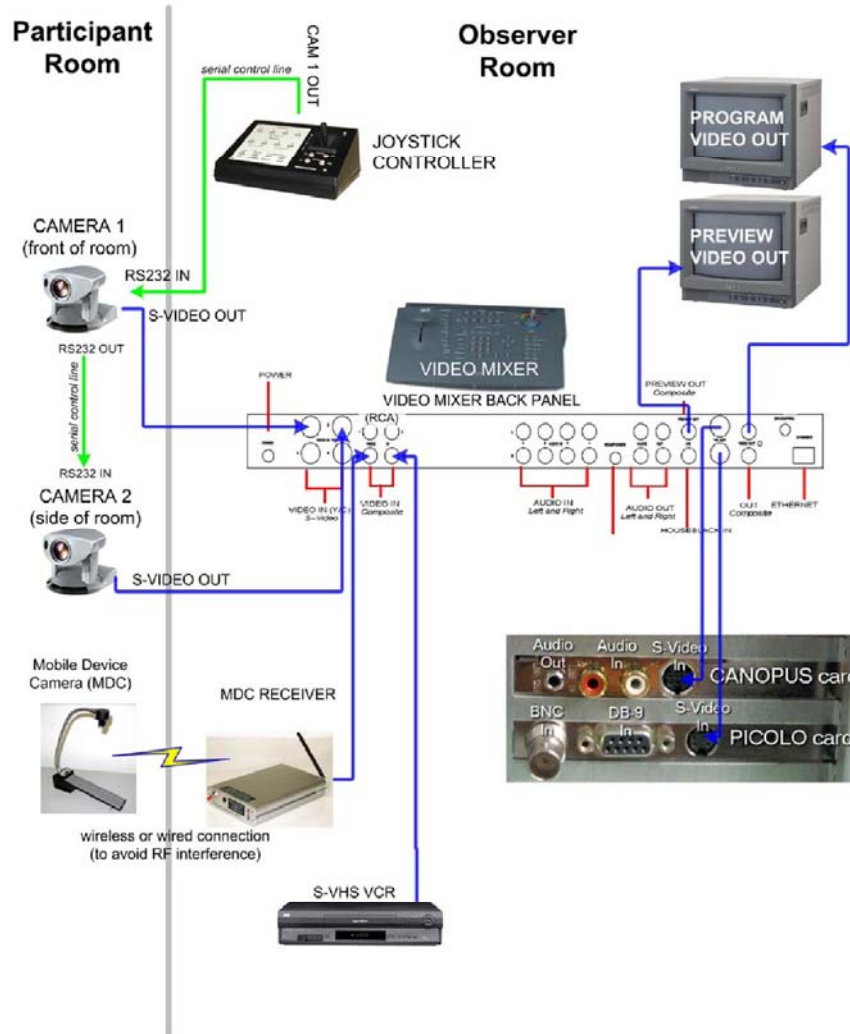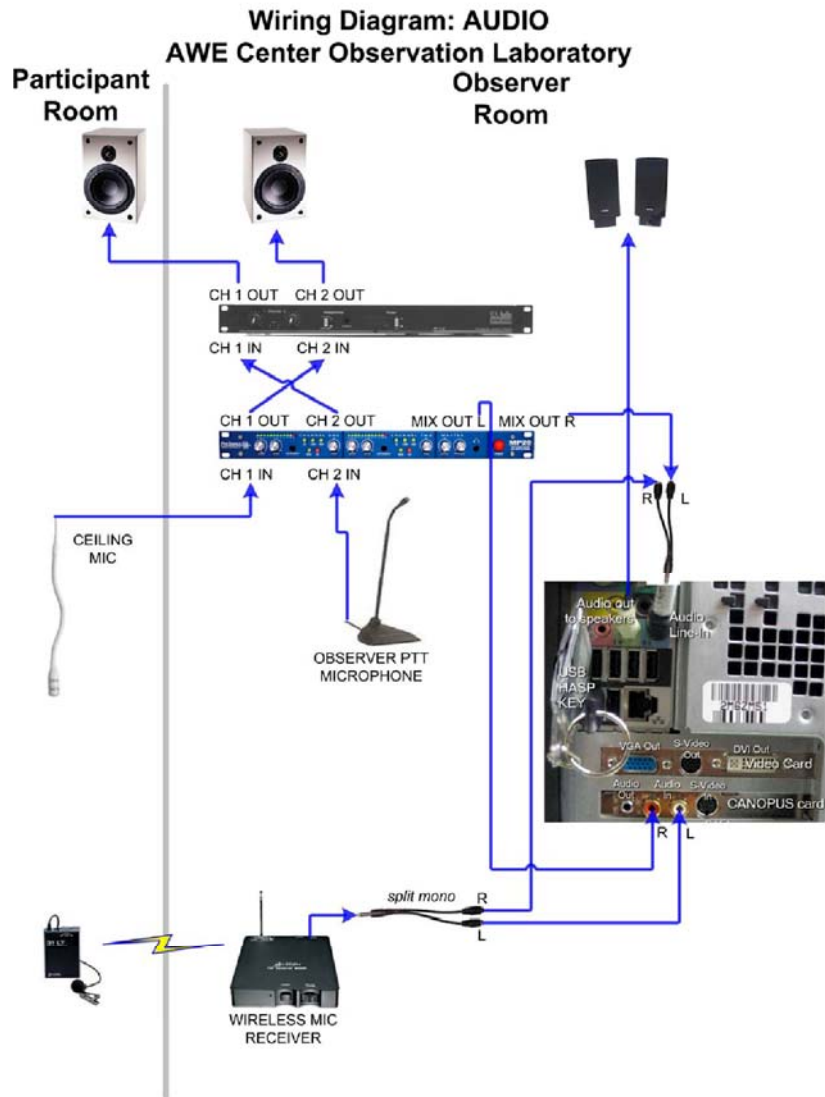
Observer workstation (simplified)

Video mixer

Audio out to speakers

Audio Line-In

USB HASP KEY

VGA Out   S-Video Out   DVI Out   Video Card

Audio Out   Audio In   S-Video In   CANOPUS card

BNC In   DB-9 In   S-Video In   PICOLO card

Firewire card
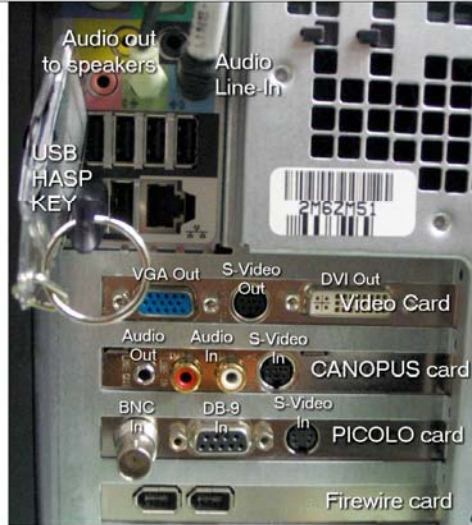
Speaker amp

Mic amp

Video mixer

Note that you can use S-Video *either/or* RCA connectors on the four inputs, and must select it via the Route menu (MX-4 manual ch 7, pg 73)

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Screen Shots of Typical Configurations

Useful desktop shortcuts to common apps (also found in Start Menu)
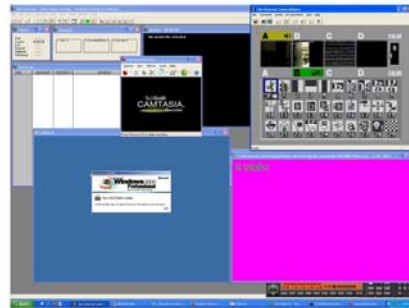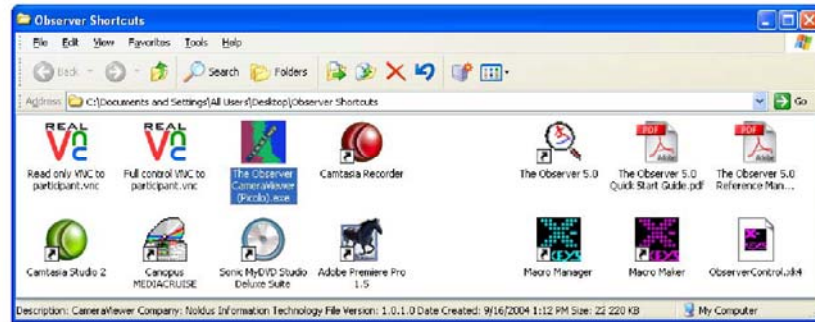
Observer running full screen in background

Camtasia recorder start/stop window

VNC to Participant workstation

Preview of Participant room in Picolo CameraViewer window

Canopus video output window (cannot be screen-captured)

Canopus recorder controller (partially hidden)
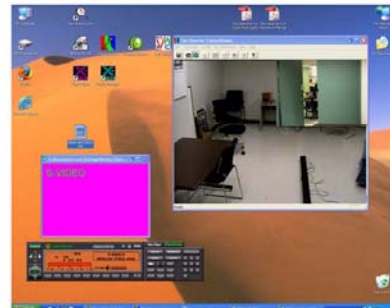
Desktop icons

Picolo CameraViewer showing Picture-in-Picture (PIP) of two cameras

Canopus recorder controller

Appendix D. Portable Observation Laboratory Embarkation List

Computer Case

(1) Laptop computer

(1) Laptop computer A/C power adapter

(1) USB mouse

(1) 1GB USB thumb drive

(2) blank CD-R media

(1) DVD+RW burner

(1) DVD+RW burner power adapter

(1) DVD+RW burner USB 2.0 connecting cable

(1) pad of writing paper

(3) pens

(3) pencils

Mobile Observer Case 1 (wireless)

(1) Mobile Device Camera (MDC)

(1) MDC receiver

(1) MDC A/C power plug

(1) MDC video cable (custom plug to RCA M)

(1) MDC battery power supply

(1) wireless mic transmitter

(1) wireless mic lapel microphone

(1) wireless mic receiver

(1) wireless mic A/C power plug

(1) wireless mic receiver cable (1/4" phono plug to dual RCA M)

(1) portable miniDV VCR

(1) portable miniDV VCR

(1) portable miniDV VCR battery

(1) portable miniDV VCR A/V input cable (3 RCA F to 1/8" plug)

(4) spare 9V batteries for MDC and wireless mic

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Mobile Observer Case 2 (camcorders)

(2) miniDV-firewire camcorders

(2) miniDV-firewire camcorder batteries

(2) miniDV-firewire camcorder A/C power adapter

(2) miniDV-firewire camcorder memory sticks for digital camera function

(2) mini tripods

(1) Large tripod ?

(2) Voice recorders

(2) External mics

(1) spare battery for miniDV camcorders and miniDV VCR

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Mobile Observer Case 3 (accessories and supplies)

(2) surge protectors

(1) 6'-10' LAN cable

(1) S-Video cable

(1) 3-way RCA patch cable

(1) Female-Female RCA connectors

(1) full-size (6-pin) firewire cable

(1) mini (4-pin) firewire cable

(1) full size USB cable

(1) mini USB cable

(10) 9V batteries for MDC and wireless mic

(20) AAA batteries for voice recorders

(10) miniDV tapes

(5) blank CD-R media

(5) blank DVD+RW media

(1) set headphones

(1) S-Video to RCA adapters

(2) BNC to RCA adapters

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Appendix E: Useful signs and displays

The following pages contain signs and displays that come in handy around the usability lab.

The original files containing these signs can be found on the CD accompanying this user's guide.

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Camera Controller Presets: Camera 1 (FRONT OF ROOM)

1 - DOOR	2 - DESK	3 - TABLE	4 – WHITE BOARD
5		6	

Camera Controller Presets: Camera 2 (SIDE VIEW)

1 - DOOR	2 - DESK	3 - TABLE	4 – WHITE BOARD
5		6	

NOTICE:
Audio and Video
Recording Equipment
may be IN USE
in this lab
at any time

RECORDING
IN
PROGRESS
quiet, please

Participant computer workstation instructions

1. Log on:

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APPENDIX C. APPLIED WARFIGHTER ERGONOMICS CENTER INFORMATIONAL MATERIALS

1. NAVAL POSTGRADUATE SCHOOL PUBLIC AFFAIRS OFFICE ARTICLE

New Applied Warfighter Ergonomics Center Measures Human-Machine Performance

Friday, February 11, 2005   Article by Javier Chagoya

U.S. Marine Corps Capt Koichi Takagi uses the Noldus Observation System in the new NPS Applied Warfighter Ergonomics Center (AWE) to gather empirical data about the interaction between human performance variables and a broad range of tactical equipment, including computer workstations, handheld devices, and weapons. Participants are asked to perform specific tasks as they are observed through a one-way mirror, as well as by remotely-controlled digital video cameras, microphones, and computer monitors that capture operator activity.

Takagi uses a special key pad to code participants' behavior. He's particularly interested in aspects of the machine-human interface considered positive or negative by users. For instance, a participant might be aggravated by a poorly designed piece of equipment, or pleased by a specific function.

Takagi's vision is to empirically evaluate human-system performance variables related to equipment designed for warfighters, and make recommendations to designers leading to improved system performance and warfighter safety.

Phase I of the project was to acquire and then master the Noldus Observation platform, a collection of off-the-shelf components and proprietary software. The equipment has an eye-tracking system that records points-of-gaze, identifies triggers of interest, and measures physical and mental workload variables, stress, dexterity, and reaction time.

In the future, Takagi plans to apply AWE's capabilities to cognitive task analyses using subject matter experts, and to record focus group and after-action report sessions. The process will also evaluate man-machine interfaces and measure the usability of hardware and software, including training effectiveness and retention. AWE's Phase II will extend the system's Phase I capabilities to field environments. Some equipment to achieve this is already in place: a portable digital camera, which attaches to a Tacticom, a hardened version of a Blackberry; and

Capt Koichi Takagi sits at the observation console where he gathers measurement data on a participant's performance in the next room.

a portable computer system for performing on site analysis.

After demonstrating AWE's capabilities to Professors' Dave Netzer and Alex Bordetsky Feb. 8, the decision was made that a network addition may soon follow. This will allow the system to transfer data seamlessly in the field, as in the laboratory.

Phase III goals are to build an anthropometrics and biomechanics laboratory to evaluate how military equipment impacts warfighters' ability to perform physical tasks. The lab will include a video-based motion capture system capable of statically and dynamically measuring size, strength, kinematics, range of motion, gait, and postural sway of warfighter subjects.

Takagi is actively looking for participants, and can be reached at the Human Systems Integration Laboratory. ktakagi@nps.edu.

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2. APPLIED WARFIGHTER ERGONOMICS OBSERVATION LABORATORY DATA SHEET

Applied Warfighter Ergonomics
Observation Laboratory Data Sheet

Technical Capabilities

□ Capture behavior in the laboratory using robotic cameras/mics and one-way mirror.

□ Capture behavior in the field using portable digital camcorders, and mobile device camera with portable miniDV VCR.

□ Mix and record audio and video from multiple live and recorded sources (including Direct screen-capture of a user's computer screen or PDA screen) onto AVI / MPEG-2 / MPEG-4 computer files, DVD, and videotape.

□ Code behavior and other events to time-stamped logs that are tied to the video files. Perform rigorous statistical analysis (including inter-rater reliability, lag-sequential analysis, and nonparametric statistics) on the results.

□ Jump to coded events on video for analysis and create video-highlight DVDs of results for sponsors and developers.

Research Capabilities

□ Observe participant(s) while using a computer or other equipment in the lab.

□ Record comments during an after-action report (AAR) de-brief.

□ Record interviews and focus group studies.

□ Record participants reactions to projected video, or to scenarios read over loudspeaker.

Examples of possible results that can be obtained

"When given the task, *'locate yourself on the [computer] map'*, 7 out of 16 participants (44%) performed it correctly within the allotted 60 seconds *(mean time to complete = 45.7s, σ = 9.8s)*, 5 participants (31%) completed the task after making one or more errors $(\mu = 88.3 s, \sigma = 15.2 s)$, and 4 participants (25%) did not complete the task within 5 minutes *(gave up or experienced a technical malfunction)*."

"Buttons 1 and 2 on the Ruggedized PDA were pressed correctly on the first try 98% of the time, button 3 was pressed correctly on the first try 87% of the time, but button 4 was pressed correctly on the first try only 45% of the time. Errors on button 4 included missing the button (28% of the time), pressing the wrong button (18% of the time), and dropping the device (9% of the time)."

"During the After Action Report (AAR) de-brief, team member #3 appeared to scowl or otherwise disagree with the team leader's comments on 6 occasions, but made no verbal comment. Members 1, 2, and 6 consistently reinforced each other's comments verbally and non-verbally."

"The equipment load as worn interfered with the participants' ability to shoulder their weapons. It increased the time to move from a standing position to a covered, kneeling firing position by an average of 3.2 seconds *(n= 21 subjects, average of 5 trials per subject, p=0.043)*. Here are some example video clips of the movement with and without the carrying load, showing how it interfered."

Koichi Takagi (11 June 2005)

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Portable Observation Laboratory

The AWE Center observation equipment has been modified at the Naval Postgraduate School to be fully portable, battery-powered, and embarkable in mil-standard transit cases. Our research capabilities, including multiple digital audio and video recording, and full computer analysis capability, can be performed on-site, afloat, in the field, and even on the move in manpack configurations.

Laboratory Observer Station Components

Observer workstation computer	Dell Dimension 8400 P4 3.2Ghz 70GB HD, 1GB RAM, Philips DVD8601 CD-RW/DVD+RW, FireWire, ATI Radeon X300 Series 128MB with special hardware and software described below
Event logging keyboard	PI Engineering X-keys SE
Camera joystick control	Telemetrics CP-ITV-VC4
Video mixer	Focus Enhancements MX-4
miniDV VCR (portable)	Sony GV-D1000
Wireless microphone receiver	Azden 200R
Mobile device camera receiver	Kern Gigasystem RX
Observer microphone	Shure MX412D/C
Mic amp	ProSonus MP20
Speaker amp	US Audio whirlwind P-12
Speakers	Radio Shack 400-4101
B&W video monitors	Show the preview and program outputs of the video mixer
One-way mirrored glass	48" x 36"

Observer workstation (special hardware and software)

Noldus HASP USB serial key License number: OB050-05422-DGAA.	Must be present to use Noldus Observer software
Noldus The Observer v5.0	Software application for coding and recording behavior
Canopus MPEG Pro MVR1000SX PCI card	Video encoder board - real-time MPEG-2 encoder from analog or DV input.
Canopus Mediacruise	Program to encode analog video input to MPEG-2 files
Canopus MVR DV-MPEG File Converter	Software to convert raw DV files to MPEG-2 format
Euresys Picolo PCI card	Video capture board (PCI slot 2).
Noldus CameraViewer	Viewer for video in to Picolo Card from video mixer
Sonic MyDVD Deluxe Suite 6.1	Software DVD player/recorder. Watch, edit, and burn DVDs
Techsmith Camtasia Studio 2.0.3	Record, edit, publish videos of PC desktop activity
RealVNC 4.0 (in viewer mode)	Observe / control the participant's computer screen
X-keys Macro Works	Controls the event logging keyboard
DivX codec 5.05, DivXplayer 2.6	Video codec and player for highly compressed DivX video files
Adobe Premier Pro 1.5	Professional video editing software

Participant station components

Participant workstation computer	Windows 2000, 512MB RAM, 2Ghz Pentium 4. Two 18 GB drives. Could be any computer, but must run RealVNC **Server** (requires admin. access to install)
Pan / tilt / zoom cameras (2)	Canon VC-C4 and VC-C50i
Ceiling microphone	Shure MX200 omnidirectional
Wireless microphone	Azden 31 LT freq: A4 171.905 Mhz
Mobile device camera	Noldus MDC-03N
Office furniture	Desk, conference table, dry-erase white board, chairs
Individual military equipment	Helmet, flak jacket, MOLLE harness and cartridge belt, rubber M-16s
GPS Rebroadcaster	GPSSource GPSRKL1-P110/5-NF transmits GPS signal indoors

Koichi Takagi (11 June 2005)

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APPENDIX D.   POINTS OF CONTACT

1.   NAVAL POSTGRADUATE SCHOOL (NPS)

Dr. Nita Miller
Director, Human Systems Integration program

Dr. Dave Netzer, Director, CDTEMS
Tactical Network Topology (TNT) program director

Marianna Verett
Dr. Netzer's research assistant, IST student

Dr. Alex Bordetsky (ITM)
cell 831-521-9196

Dr. Eugene Bourakov (ITM)

Dr. Kevin Jones
Mech Engr, TNT Aeronautics expert

Ryan Hale
Systems Engineering special contract research assistant

Francisco Caceres
Capt, USMC. ITM Student with RPDA knowledge and contacts

Maj Carl Oros, USMC
IST faculty

Tom Hyunh
John Osmundson
Systems Engineering

LT Lani Bostick
NPS Supply Officer, Navy Region Southwest, x2236
(past ballroom, 1st deck Hermann Hall by comptroller)

Matt Simpson
1stLt, USAF. HSI Student.

Derek Read
1stLt, USAF. HSI Student.

Koichi Takagi
Capt, USMC. OR / MBA Student
Naval Postgraduate School, (OA Code 61)
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Chris White
Navy Human Performance Center

Jeff Rothal
Reference and Instruction Librarian for Operations Research
(831) 656-2344
jrothal@nps.edu

2.   RPDA MANUFACTURERS

Points of contact to the specific RPDA manufacturers is available in a separate file, by contacting the Operations Research department at the Naval Postgraduate School.

3.   SPONSORS AND OTHER AGENCIES

United States Army Special Operations Command (USASOC)
Ft. Bragg, Fayetteville, NC
Brian Kent (LtCol - PM at JSOC, handles money)
brian.l.kent@us.army.mil (910) 243-0451, cell (910) 670-8976
MAI (Mobile Access Infrastructure)
Joint Tactical C4I

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DSN: 654-2247
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FAX: (703) 704-4224
http://www.ref.army.mil/

4.   LABORATORY EQUIPMENT SUPPLIERS

Noldus Information Technology Inc.
751 Miller Drive, Suite-E-5
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Phone: 703-771-0440/800-355-9541
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5. **DEFENSE LANGUAGE INSTITUTE (DLI) AT THE PRESIDIO OF MONTEREY (POM)**

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Marine Corps Detachment (MarDet)
Executive officer (XO)
Capt Raymond Servano
raymond.servano@monterey.army.mil
(831) 242-5757

MarDet S-4/Supply
Source to temp-loan helmets, flak jackets, packs, 782 gear
242-6854

Deck Gunny
POC for USMC casuals
SSgt Boissoneau   nathan.boissoneau@monterey.army.mil
242-5873

S-3 Operations
SSgt Murray   keevin.murray@monterey.army.mil

229th Military Intelligence (MI) Bn
S-3 (Operations)
SFC Swanson
242-5295, 242-5208
Source to temp-loan military equipment and coordinate DLI Army "casuals" (students not currently in training). "DSSOPS" is in charge of all DLI casuals.

Chief Hernandez baltazar.hernandez@monterey.army.mil
Person to send Casual Request Form to

Williamson,   John   C.   (SSG)
     John.Williamson@monterey.army.mil
Person who handles casuals for 229MI Bn.

Bumann,   Gregory   (SSG)
        Gregory.bumann@monterey.army.mil
242-5796
NCO in charge of B Co casuals. B Co may have better participants and availability for research.
Drill Sgt Stroud
Bldg 622 ("Bn Mailroom" etc.), 2nd floor
From NPS: take Del Monte to Van Buren, left on Van Buren, right on Franklin St, enter DLI Franklin St. gate, take first left (Rifle Range Rd.), enter parking lot on left.

Petty Officer McGuire david.mcguire@cnet.navy.mil
PO Buchanan benjamin.buchanan@cnet.navy.mil
242-7125
In charge of Navy detachment casuals only. Might be easier to coordinate directly with them to request Navy-only casuals.

APPENDIX E.   SURVEYS

1.   TECHNOLOGY EXPERIENCE SURVEY

Participant ID # [   ]

Technology Experience Survey

Instructions: Please circle the response or enter an answer that most accurately describes your experience with the following technologies. If you are not sure about an answer, make your best guess.

Cell Phone Experience

1. Do you have a cell phone? (if **NO,** skip to question 7)	**[YES] [NO]**
2. Approximately how often do you talk on your cell phone?	*Please enter a number* _____**(hours per week)**
3. Approximately how often do you use text messaging on your cell phone?	_____**(hours per week)**
4. Approximately how often do you customize your cell phone (change ring tones, background pictures, etc.)?	_____**(hours per week)**
5. Approximately how often do you play games or use other programs on your cell phone?	_____**(hours per week)**
6. Approximately how many phone numbers are stored on your cell phone phonebook?	

Personal Digital Assistant (PDA) Experience

PDAs include Palm Pilots, Pocket PCs, personal organizers, and similar devices.

7. I use a PDA: (Please circle one)

1 never used	2 used in the past, but not now	3 currently use, less than 30 min per week	4 currently use, 30 min per week or more

8. My experience with a PDA stylus: (A "stylus" is a small pen used to write on a PDA screen.)

1 never used	2 used in the past, But didn't like it	3 used in the past, and think they're OK	4 used in the past, and think they're great

Video Game Experience

9. How many hours per week do you play video games?	_____**(hours per week)**
10. I play online video games.	**[YES] [NO]**
11. I play video games on a home computer.	**[YES] [NO]**
12. I play video games on a video game system (Playstation, X-Box, etc.).	**[YES] [NO]**
13. If you play video games, please list a few of your favorite video games. `	

Computer Experience (Please circle one)

14. I have a computer at work that is primarily for my own use.	[YES] [NO]
15. I have a computer at work that I share with others.	[YES] [NO]
16. I never or almost never use a computer at work.	[YES] [NO]
17. I use a computer in my living quarters.	[YES] [NO]
18. I use public computers (at a library, internet café, base facility, etc.)	[YES] [NO]
19. I often use several programs at the same time.	[YES] [NO]

20. If I had a problem while using a computer, I would:
    Number all that apply, in the order that you might perform them.

       _____ **a. Stop trying, and do something else.**
       _____ **b. Read the manuals.**
       _____ **c. Read the help files on the computer.**
       _____ **d. Ask someone for help.**
       _____ **e. Keep trying different ways to do it.**

	Please enter an approximate number
21. I use a computer…	_____ **(hours per week)**
22. I send and receive email messages…	_____ **(hours per week)**
23. I send and receive email attachments…	_____ **(hours per week)**
24. I use online chat or instant messaging…	_____ **(hours per week)**
25. I use the internet to find information…	_____ **(hours per week)**
26. I shop or browse online…	_____ **(hours per MONTH)**
27. I use online banking services…	_____ **(hours per MONTH)**
28. I trust computers to store sensitive personal information.	[YES] [NO]

Military Technology Experience
(**expert** = qualified to teach the subject)

1=novice ⟶ 5= expert

	please circle one
29. Military radio equipment.	[N/A] [1] [2] [3] [4] [5]
30. Military GPS (PLGRS).	[N/A] [1] [2] [3] [4] [5]
31. Standard topographical map.	[N/A] [1] [2] [3] [4] [5]
32. Standard military compass.	[N/A] [1] [2] [3] [4] [5]
33. FBCB2 or Blue Force Tracker.	[N/A] [1] [2] [3] [4] [5]
34. Tacticomp (indicate when)	[N/A] [1] [2] [3] [4] [5]
35. Commander's Digital Assistant or other handheld computer (please describe).	[N/A] [1] [2] [3] [4] [5]

Demographic Information

36. Age (in years)	
37. Gender	[MALE] [FEMALE]
38. Pay grade (E-3, O-2, etc.)	
39. Branch of Service (USA, USMC, etc.)	
40. Total years of enlisted service	
41. Total years of commissioned service	
42. Designator, MOS, or rating (e.g SWO, 0602 CommO, 11B Infantry, etc.)	
43. Level of education (please check one)	___ 1. less than high school ___ 2. high school graduate or GED ___ 3. some college ___ 4. college graduate ___ 5. graduate degree
44. Current duty assignment or billet description (e.g. intelligence analyst, machine gunner, etc.)	

45. Special schools and qualifications (circle all that apply, and write in any others)

[a. Ranger]   [b. Pathfinder]   [c. EIB]   [d. Air Assault]

[e. NCO course]   [f. SNCO course]   [g. Computer Training]   [h. HALO]
                                              please describe

Other courses:

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2.   HANDHELD DEVICE EVALUATION

Participant ID # [   ]

Handheld Device Evaluation

Instructions: Please circle the response or write an answer that most accurately describes your experiences during today's scenario. Please describe your experiences only during today's scenario. Even if you evaluated a particular feature during a previous scenario, describe your new experience with the equipment today. Don't fill in the same answer as before, unless your opinion is exactly the same.

Use additional space on the back of the form as needed. Your detailed additional comments are some of the most useful results we obtain in this study. Please be frank and honest – all responses will be kept completely anonymous.

Scenario

1. Location	
2. Date	

3. Brief description of what I did during this scenario:

Communications and networking

4. Description of the communications and networking features I used in this scenario.

5. Number of text messages *sent. (best guess)*
a. # Attempted: _____   **b. # Successful:** _____

6. Satisfaction with the text messages I sent: ease of input, speed and accuracy of entering text, knowing when a message was sent and received by the recipient.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

7. Number of text messages *received. (best guess)*
a. # Attempted: _____   **b. # Successful:** _____

8. Satisfaction with the text messages I received: ease of retrieving and reading, knowing when a message has been received, accuracy of messages.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

9. Satisfaction with the communications and networking functions in this scenario.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	[2]	[3]	[4]	[5]	[N/A]

additional comments:

10. Satisfaction the reliability of the communications and networking functions in this scenario.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	[2]	[3]	[4]	[5]	[N/A]

additional comments:

User interface - software

11. Satisfaction with the quality of still images displayed (how well could I interpret the images displayed).

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	[2]	[3]	[4]	[5]	[N/A]

additional comments:

12. Number of moving videos I viewed in this scenario. *(best guess)*

a. # Attempted: _____   **b. # Successful: _____**

13. Satisfaction with the quality of moving video displayed (how well could I interpret the video displayed).

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	[2]	[3]	[4]	[5]	[N/A]

additional comments:

14. Number of audio files I listened to in this scenario. *(best guess)*

a. # Attempted: _____   **b. # Successful: _____**

15. Satisfaction with the quality of audio files (how well could I interpret the audio presented).

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	[2]	[3]	[4]	[5]	[N/A]

additional comments:

16. Number of times I used the mapping functions during this scenario. *(best guess)*

      a. # Attempted: _____   **b. # Successful: _____**

17. Satisfaction with the mapping functionality (how well could I interpret the map, find myself and other places on the map, how it compared to a paper map).

very dissatisfied [1]	somewhat dissatisfied [2]	neutral [3]	somewhat satisfied [4]	very satisfied [5]	[N/A]

additional comments:

18. Satisfaction with the situational awareness tools: how well I knew where myself, and friendly and enemy units *actually were* (not just where the computer said they were). Also, how well I knew when the information displayed was old or possibly incorrect.

very dissatisfied [1]	somewhat dissatisfied [2]	neutral [3]	somewhat satisfied [4]	very satisfied [5]	[N/A]

additional comments:

User interface - hardware

19. Number of times I used the stylus to operate the device during this scenario. *(best guess)*

      a. # Attempted: _____   **b. # Successful: _____**

20. Satisfaction with using the stylus during this scenario. Please comment on issues experienced.

very dissatisfied [1]	somewhat dissatisfied [2]	neutral [3]	somewhat satisfied [4]	very satisfied [5]	[N/A]

additional comments:

21. Number of times I used the buttons to operate the device during this scenario. . *(best guess)*

      a. # Attempted: _____   **b. # Successful: _____**

22. Satisfaction with using the buttons on the device during this scenario. Please comment on issues experienced.

very dissatisfied [1]	somewhat dissatisfied [2]	neutral [3]	somewhat satisfied [4]	very satisfied [5]	[N/A]

additional comments:

23. Satisfaction with *one-handed* operation of the device during this scenario. Please comment on issues experienced.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

24. Satisfaction with removing the device from my gear or carrying position to use it during this scenario.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

25. Satisfaction with stowing the device on my gear when not needed during this scenario

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

26. Ability to use my personal weapon while operating the device.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

27. Ability to read the screen under various conditions (sun, glare, shadows, night, etc.)

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

Overall system

28. Satisfaction with the reliability of the system to perform its functions in this scenario, without malfunctioning, crashing, freezing, incorrect displays, or other errors. *List types of malfunctions experienced.*

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

29. Satisfaction with the physical ruggedness of the system to perform under the conditions of the scenario. *List any breakdowns your device experienced.*

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

30. Overall impression of the system during this scenario.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

31. Impression of how easy this system is to learn and use for me and people like me.

very dissatisfied	somewhat dissatisfied	neutral	somewhat satisfied	very satisfied	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[N/A]**

additional comments:

Free comments

32. Please take as much room as you require, on this sheet and on the back of the other sheets, to record any suggestions, concerns, and random thoughts that occurred to you during this scenario. Thank you for your full participation in this survey.

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APPENDIX F.   USABILITY TEST SCENARIO

1.   INSTRUCTIONS AND SETUP
Instructions for participants

This scenario is somewhat artificial, and some parts may not make sense tactically or realistically. Do your best to keep a tactical mindset and respond appropriately. As a patrol leader, you should write down any instructions you receive over the loudspeakers (not the video), because you may need to brief your patrol later. You should ignore any grid coordinates given in the video.

You should take a knee, or otherwise react to the scenario as you might in a real situation. Please stay over the "X" on the floor.

Your call sign is "Alpha-Six", or just "Six"
You are talking to "Alpha Company HQ" on the radio and on the RPDA.
If instructed to "tell your patrol" something, just read it out loud in a clear voice as if they were in front of you.
Tell your patrol any messages you receive over the RPDA.

Familiarize yourself with the following points on the map. When plotting, use the closest location on the map that makes sense to you.
Plot routes *directly* from point to point – do not try to stay on the roads.

Point Pinos
Bird Rock
Pescadero Point
Pebble Beach Quarry
AlphaSix Patrol Base (blue rectangle in Pebble Beach)
Alpha Company HQ (blue rectangle at the Presidio)
Naval Postgraduate School
Monterey Peninsula Airport (use center of runways as point of reference)
Monterey Commercial Pier (the easternmost pier)

A "QRF" is a Quick Reaction Force.

Setup

Plug S-VIDEO and AUDIO (headset) cables into laptop.

Set up laptop for dual screen:
Right click on desktop -> Properties -> Settings tab ->
click monitor 2: Resolution 800x600,
Extend my Windows desktop on this monitor.

Run CDR 32: Combined Action in Iraq
      Screen mode: Dual-Screen
      Facilitator notes: Learn
      Language: English

To play a video in the CDR, click on the line of text, not the icon.

2. CONVENTIONAL EQUIPMENT SEGMENT (Z)

Tasks: 1c, 2c, 5c, 6c, 3c, 5c *(2nd time),* 6c *(2nd time),* 7c, 6c*(3rd time),* 4c

(Z - Conv. Equipment)		
Facilitator	**Participant**	**Task Evaluated**
1. As a group, orient participants to the important points on the map (listed in Participant Instructions). 2. As a group, play video of RPDA instruction to review functionality. 3. Allow participants 10 minutes to practice on RPDAs. 4. Answer any questions about the lab environment or the RPDAs.		
5. Have participant dress into their gear and calibrate the RPDA. Take a pencil, notepad, protractor, and blank map. Write participant number on map and first page of notepad. 6. **Start recording** on observer computer.		(Scenario setup)
7. **Instruction**: "State your participant number."	States participant number out loud.	
8. **Instruction**: "Break out your map and note taking gear and stand by for your patrol order. Disregard the coordinates given in the video." **Play** CDR note 13. (METT-T order) **Play** title screen (to take the METT-T order off of screen)	Watch video	

| (Z - Conv. Equipment) | | Task |
Facilitator	Participant	Evaluated
9. Orient participant to map: **Instruction**: "You are currently at the patrol base located at grid 939506."	Listen, read map	
10. **Instruction**: "Send a radio check to Alpha Company HQ" <mark>Radio</mark>: "Roger, over"	Turn on radio. Send voice comm check. "Alpha Company HQ, Radio check, over" "Roger, Alpha-Six, out"	1c comm chk
11. **Instruction**: "Plot a direct patrol route with two legs from the Patrol Base, to Cypress Point, ending at Pescadero Point. Give us a thumbs up when you are done."	Plots route on map	2c plot rte *take part-icipant off and on task as he reads info or receives instructions*
12. **Instruction**: Tell your patrol the six digit grid coordinates of each point."	Reads out loud three grids: 939 506 916 487 938 465	
13. **Instruction**: "Tell your patrol the bearing and range of the first leg, and the total distance of the trip."	Reads out loud bearing and range and total distance. 234°, 3100m Total: 6200m	
14. **Instruction**: "You take your patrol on the road'	Watch video.	
15. **Play** CDR note 17. (IED goes off)	Watch video	
16. **Instruction**: "You currently are at Bird Rock. Get on the radio and tell Alpha Company you've been ambushed." **Play** note 18. (sporadic fire)	Radio: "Alpha company, we've been ambushed"	5c send msg
17. <mark>Radio</mark>: "Roger, dismount and engage the enemy. What is your current grid?"	Reads paper map. Radio "I am at grid 925 499 "	6c rcv msg 3c read grid

| (Z - Conv. Equipment) | | Task |
Facilitator	Participant	Evaluated
18. **Play** CDR note 20. (2 Marines down) Instruction: "Request an URGENT MEDEVAC FOR TWO MARINES WITH GUNSHOT WOUNDS AND HEAVY BLEEDING"	Radio: REQUEST AN URGENT MEDEVAC FOR TWO MARINES WITH GUNSHOT WOUNDS AND HEAVY BLEEDING	5c send msg
19. **Radio**: "Roger, medevac on the way." **Play** CDR note 21. (Helo Medevac)	Watch video.	
20. **Instruction**: "You are now at Pescadero Point." **Play** CDR note 28 [Page 2]. (arrive at house)	Watch video.	
21. **Radio**: "Alpha Six, what were the grid coordinates of your original patrol route?"	Radio: Reads back grids from notebook. 939 506 916 487 938 465	6c rcv msg 7c read back
22. **Radio**: "Be prepared to displace to rally point at the Pebble Beach Quarry grid 958 491"	Radio: "Roger" Copies down grid	6c rcv msg
23. **Instruction**: "Tell your patrol the bearing and range to the new rally point".	Uses paper map. Reads out loud bearing and range: 36°, 3300m	4c brg rng

3. RPDA SEGMENT OF SCENARIO: RPDA-A

Tasks: 1a, 5a, 6a, 3a, 4a, 5a *(2nd time),* 6a *(2nd time),* 7a, 4a *(2nd time)*

(RPDA-A) Facilitator	Participant	Task Evaluated
1. **Instruction**: "Stow your radio and map and deploy the RPDA at this time. Announce out loud to your patrol any instructions received on the RPDA. You currently are at the Naval Postgraduate School"	Take out RPDA	
2. **Instruction**: "Send comm check"	RPDA: "comm check"	1a comm. chk
3. **Play** CDR note 30. (enter house) **Instruction**: "Send a message to Alpha Company HQ telling them you FOUND SUSPECT WITH WIFE, SEVEN CHILDREN, TEN RELATIVES, ONE AK-47' **Play** sporadic gunfire **Play** note 31 (Police) **repeatedly**	RPDA: 'FOUND SUSPECT WITH WIFE, SEVEN CHILDREN, TEN RELATIVES, ONE AK-47'	5a send msg
4. **RPDA**: "BRING SUSPECT TO HQ"	Read RPDA. Say, "BRING SUSPECT TO HQ".	6a rcv msg
5. ~~**Instruction**: "Plot a route with two legs from your location to the rally point and then back to A CO HQ at _____"~~ *task omitted* **Instruction:** "The new checkpoint is at the intersection of Hwy 68 and Route 1. The Alpha Co XO is at the commercial pier.	~~Plots route on RPDA~~ *task omitted*	~~2a plot rte~~ *task omitted, not supported by RPDA*

(RPDA-A)		
Facilitator	**Participant**	**Task Evaluated**
6. **Instruction**: "Tell your patrol the 6-digit grid coordinates of each point" *note that RPDA-A was not calibrated to the correct grid coordinates on a paper map.*	Reads out three loud grids from RPDA: A6. Checkpoint. A Co XO at commercial pier. *(acceptable if the participant taps in the right vicinity and reads grid correctly)*	3a read grid
7. **Instruction**: "Tell your patrol the bearing and range to the checkpoint. *and the total distance of the trip*	Reads out loud bearing and range, ~~and total distance~~ *(not supported by RPDA)* 121°, 566m	4a brg rng
8. **Play** CDR note 33. (angry mob) Instruction: "Send a message to Alpha Company telling them 'ANGRY MOB BLOCKING WITHDRAWAL'	RPDA: "ANGRY MOB BLOCKING WITHDRAWAL"	5a send msg
9. **RPDA**: "ROGER. QRF ENROUTE" **Play** CDR note 35. (QRF arrives)	Say, "QRF Enroute". Watch video	6a rcv msg
10. **Instruction**: "The Alpha Company commander has arrived with the Quick Reaction Force. He asks you to read out loud the message that you previously sent on your RPDA about what you found at the house.	Go through message log and read back message.	7a read back

| (RPDA-A) | | Task |
Facilitator	Participant	Evaluated
11. The A Co Commander instructs you to proceed directly to Monterey Airport, rather than go through the rally point. Tell your patrol the bearing and range from your location straight to the Monterey Airport."	Reads bearing and range off of PDA: 113°, 2000m	4a brg rng
12. **Play** note 36. **Instruction**: "The QRF subdues crowd and you return to base. The mission is a success. Stow your RPDA and your gear at this time. END OF MISSION." **Stop** video recording. **Instruction**: "Please return your pencil, protractor, map, and notepad to the table"	Watch video. Return RPDA to table. Remove gear and exit room.	
13. Give participants the Technology Experience Survey to complete.	Complete survey, dismissed.	

4.   RPDA SEGMENT OF SCENARIO: RPDA-B

Tasks: 3a, 5a

(RPDA-B)		
Facilitator	**Participant**	**Task Evaluated**
1. **Instruction**: "Prepare the RPDA at this time."	Take out RPDA	
2. **Instruction**: "Find the grid coordinates of the commercial pier, the Monterey airport, and the Naval Postgraduate School."	Reads out loud grids from RPDA: 994 510 027 498 008 508 *(grids may be considerably different on RPDA if the map image has not been aligned)*	3a read grid
3. **Instruction:** "Go to the Start Menu and use the Text Chat application. Send a text message requesting an 'URGENT MEDEVAC FOR TWO MARINES WITH GUNSHOT WOUNDS AND HEAVY BLEEDING' "	RPDA: REQUEST URGENT MEDEVAC FOR TWO MARINES WITH GUNSHOT WOUNDS AND HEAVY BLEEDING	5a send msg

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5. RPDA SEGMENT OF SCENARIO: RPDA-C

(RPDA-C) Facilitator	Participant	Task Evaluated
1. **Instruction**: "Stow your radio and map and deploy the RPDA at this time. Announce out loud to your patrol any instructions received on the RPDA. You currently are at the Naval Postgraduate School"	Take out RPDA	
2. **Instruction**: "Send comm check"	RPDA: "comm check"	1a comm. chk
3. **Play** CDR note 30. (enter house) **Instruction**: "Send a message to Alpha Company HQ telling them you FOUND SUSPECT WITH WIFE, SEVEN CHILDREN, TEN RELATIVES, ONE AK-47' **Play** sporadic gunfire **Play** note 31 (Police) **repeatedly**	RPDA: 'FOUND SUSPECT WITH WIFE, SEVEN CHILDREN, TEN RELATIVES, ONE AK-47'	5a send msg
4. **RPDA**: "BRING SUSPECT TO HQ"	Read RPDA. Say, "BRING SUSPECT TO HQ".	6a rcv msg
5. ~~**Instruction**: "Plot a route with two legs from your location to the rally point and then back to A CO HQ at _____"~~ *task omitted* **Instruction:** "The new checkpoint is at the intersection of Hwy 68 and Route 1. The Alpha Co XO is at the commercial pier.	~~Plots route on RPDA~~ *task omitted*	~~2a plot rte~~ *task omitted, not supported by RPDA*

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| (RPDA-C) | | Task |
Facilitator	Participant	Evaluated
6. **Instruction**: "Tell your patrol the 6-digit grid coordinates of each point"	Reads out loud grids from RPDA: 938 465 958 491 974 513	3a read grid
7. **Instruction**: "Tell your patrol the bearing and range to the checkpoint. *and the total distance of the trip*	Reads out loud bearing and range, ~~and total distance~~ *(not supported by RPDA)*	4a brg rng
8. **Play** CDR note 33. (angry mob) Instruction: "Send a message to Alpha Company telling them 'ANGRY MOB BLOCKING WITHDRAWAL'	RPDA: "ANGRY MOB BLOCKING WITHDRAWAL"	5a send msg
9. **RPDA**: "ROGER. QRF ENROUTE" **Play** CDR note 35. (QRF arrives)	Say, "QRF Enroute". Watch video	6a rcv msg
10. **Instruction**: "The Alpha Company commander has arrived with the Quick Reaction Force. He asks you to read out loud the message that you previously sent on your RPDA about what you found at the house.	Go through message log and read back message.	7a read back
11. The A Co Commander instructs you to proceed directly to Monterey Airport, rather than go through the rally point. Tell your patrol the bearing and range from your location straight to the Monterey Airport."	Reads bearing and range off of PDA: 73°, 9400m	4a brg rng

(RPDA-C)		
Facilitator	Participant	Task Evaluated
12. **Play** note 36. **Instruction**: "The QRF subdues crowd and you return to base. The mission is a success. Stow your RPDA and your gear at this time. END OF MISSION." **Stop** video recording. **Instruction**: "Please return your pencil, protractor, map, and notepad to the table"	Watch video. Return RPDA to table. Remove gear and exit room.	
13. Give participants the Technology Experience Survey to complete.	Complete survey, dismissed.	

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6. RPDA SEGMENT OF SCENARIO: RPDA-D

Tasks: 1a, 5a, 6a, 2a, 3a, 4a, 5a *(2nd time)*, 6a *(2nd time)*, 7a, 4a *(2nd time)*

(RPDA-D)		
Facilitator	**Participant**	**Task Evaluated**
1. **Instruction**: "Stow your radio and map and deploy the RPDA at this time. Announce out loud to your patrol any instructions received on the RPDA."	Take out RPDA	
2. **Instruction**: "Send comm check"	RPDA: "comm check"	1a comm. chk
3. **Play** note 30. (enter house) **Instruction**: "Send a message to Alpha Company HQ telling them you FOUND SUSPECT WITH WIFE, SEVEN CHILDREN, TEN RELATIVES, ONE AK-47' **Play** sporadic gunfire **Play** note 31 (Police) **repeatedly**	RPDA: 'FOUND SUSPECT WITH WIFE, SEVEN CHILDREN, TEN RELATIVES, ONE AK-47'	5a send msg
4. **RPDA**: "BRING SUSPECT TO HQ"	Read RPDA. Say, "BRING SUSPECT TO HQ".	6a rcv msg
5. **Instruction**: "Plot a route with two legs from your location to the rally point and then back to A CO HQ at 974 513"	Plots route on RPDA	2a plot rte
6. **Instruction**: "Tell your patrol the 6-digit grid coordinates of each point"	Reads out loud grids from RPDA: 938 465 958 491 974 513	3a read grid

(RPDA-D)		
Facilitator	**Participant**	**Task Evaluated**
7. **Instruction**: "Tell your patrol the bearing and range of the first leg, and the total distance of the trip."	Reads out loud bearing and range, and total distance: 36°, 3300m total: 6400m	4a brg rng
8. **Play** note 33. (angry mob) Instruction: "Send a message to Alpha Company telling them 'ANGRY MOB BLOCKING WITHDRAWAL'	RPDA: "ANGRY MOB BLOCKING WITHDRAWAL"	5a send msg
9. **RPDA**: "ROGER. QRF ENROUTE" **Play** note 35. (QRF arrives)	Say, "QRF Enroute". Watch video	6a rcv msg
10. **Instruction**: "The Alpha Company commander has arrived with the Quick Reaction Force. He asks you to read out loud the message about what you found at the house, that you previously sent on your RPDA.	Go through message log and read back message.	7a read back
11. The A Co Commander instructs you to proceed directly to Monterey Airport, rather than go through the rally point. Tell your patrol the bearing and range from your location straight to the Monterey Airport."	Reads bearing and range off of PDA: 73°, 9400m	4a brg rng

(RPDA-D)		Task Evaluated
Facilitator	**Participant**	
12. **Play** note 36. **Instruction**: "The QRF subdues crowd and you return to base. The mission is a success. Stow your RPDA and your gear at this time. END OF MISSION." **Stop** video recording. **Instruction**: "Please return your pencil, protractor, map, and notepad to the table"	Watch video. Return RPDA to table. Remove gear and exit room.	
13. Give participants the Technology Experience Survey to complete.	Complete survey, dismissed.	

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7. TACTICAL SCENARIO MAP

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APPENDIX G.   RPDA TRAINING

1.   RPDA-A LESSON PLAN BRIEF

Slide 1

Advanced Soldier C2 Capabilities
RPDA's

NPS
PRAESTANTIA PER SCIENTIAM

By: Mr. Cyle Fena
Military Advisor

Slide 2

ADVANCED SOLIDER C2 CAPABILITIES

PURPOSE: The purpose of this training is to familiarize DLI Students with the basic functionality and characteristics of the RPDA-A software with an emphasis on situational understanding, voice communications, and text messaging through a multiplex radio RPDA-Architecture.

Slide 3

ADVANCED SOLDIER C2 CAPABILITIES

AGENDA

HISTORICAL BACKGROUND
TRAINING OBJECTIVES
DESCRIPTION
RPDA-AHITECTURE
SOFTWARE FAMILIARIZATION
SYSTEM START UP
RPDA-A FUNCTIONS
PRACTICAL APPLICATION
REVIEW/ AAR

Slide 4

ADVANCED SOLDIER C2 CAPABILITIES

RPDA-A FAMILIARIZATION

TASK: Become familiar with basic RPDA-A software components.

CONDITIONS: Given a classroom environment, one primary instructor, all components of the RPDA-A and RPDA-B systems with appropriate media, and training aids.

STANDARDS: Become familiar with the software and all components of the RPDA-A and TACICOMP system RPDA-Ahitecture.

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ADVANCED SOLDIER C2 CAPABILITIES

RPDA-A FAMILIARIZATION

There are *five* basic components of the RPDA-A:

Soldier PDA
Radio (Short Range)
GPS/ Battery Box Adapter
Headset
Push to Talk Button

Slide 6

ADVANCED SOLDIER C2 CAPABILTIES

SOLDIER RPDA
➢ Provides core capabilities
  – Mapping
  – Messaging
  – Voice over IP
➢ Provides extended capabilities
  – PackBot Control
  – Robotic ATV Control
  – Weapons Control
  – Sensor Monitoring

ADVANCED SOLDIER C2 CAPABILITIES

DIGITAL RADIO

- 802.11b WiFi based radio
  - 2.4GHz, 11 channels (3 non-overlapping)
- Network radio
  - Multi-Hop (>5)
  - Bridging/Routing
- 2.4–0.6 mbps max throughput for 1–4 hops
- Internal battery with ~60 minutes reserve

RF Range: ~400m LOS per hop
Weight: 2 lbs
Power: 3.2 W

ADVANCED SOLDIER C2 CAPABILITIES

GPS/ BATTERY BOX

➤ Standard military battery with enclosed case
  - BA5590 family.
➤ Cables with connectors are permanently attached to the battery box ('flying leads').
➤ 12 Channel WAAS GPS.
➤ Power conditioning.
➤ Headphone jack for radio voice communications.

ADVANCED SOLDIER C2 CAPABILITIES

Assembly and Start-Up

ADVANCED SOLDIER C2 CAPABILITIES

SYSTEM ASSEMBLY AND START UP

TASK: Place the RPDA-A into Operation.

CONDITIONS: Given a classroom environment, one primary and several assistant instructors, all assembled components of the RPDA-A system with appropriate media, and training aids.

STANDARDS: Successfully assemble and initialize the RPDA-A so that it provides Situational Understanding, VOIP Communications, Robotic Control, and Text Messaging.

ADVANCED SOLDIER C2 CAPABILITIES

Components

RPDA-A PDA W/ mount
GPS/ Battery Box and Housing
Audio Cable w/ PTT Assembly
Headset w/ MIC
Flexible Antenna
Short Range Radio w/ MOLLE Mount
Joystick Controller

Shown with load-bearing vest

ADVANCED SOLDIER C2 CAPABILITIES

ASSEMBLY

CAUTION: When installing cables do not crimp, force or pull cables. All cables are designed for a precision fit

RPDA-A assembled on a MOLLE configured assault pack

RPDA-A assembled on a MOLLE load-bearing vest

ADVANCED SOLDIER C2 CAPABILITIES

ASSEMBLY

RPDA-A assembled on Body Armor

RPDA-A assembled on body armor in Afghanistan

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ADVANCED SOLDIER C2 CAPABILITIES

ASSEMBLY

Note: Inspect all components for damage prior to assembly.

1. Insert Battery into combination GPS/ Battery Box Housing.
2. Secure butterfly connectors on the sides of the Battery Box Housing.
3. Insert combination PTT/ Headset into cable labeled "Audio."

GPS/ Battery Box Housing

Audio/ Push To Talk

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ADVANCED SOLDIER C2 CAPABILITIES

ASSEMBLY

1. Insert Primary RPDA Cable into RPDA; place thin portion of cable through Cable Retainer and gently pull cable rearward.
2. Slide cannon plug of cable forward, with the slotted portion up, until the plug is firmly seeded into the RPDA.
3. Rotate the plug bezel in a clockwise motion until tightened.

PDA Cable Assembly

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ADVANCED SOLDIER C2 CAPABILITIES

ASSEMBLY

1. Connect quick Release radio plugs to GPS/ Battery Box Housing cable labeled "Radio."

Quick disconnect for radio and headset

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ADVANCED SOLDIER C2 CAPABILITIES

ASSEMBLY

1. Place two-way spring loaded radio power toggle in the "on" position. (Toggle should be pointed toward the antenna).

POWER TOGGLE

Digital radio two-way power toggle

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ADVANCED SOLDIER C2 CAPABILITIES

TROUBLE SHOOTING

PDA Screen Disappears

1. In the event the RPDA-A PDA screen disappears perform the following steps.
2. Ensure the RPDA-A PDA cable is firmly seeded into the PDA.
3. Check to see if Radio switch is in the "ON" position, antenna is connected securely, and has proper orientation.
4. Ensure battery is secure and correctly inserted into GPS/ Battery Box Housing.
5. Press "RESET" and re-enter correct organizational data, and re-initialize RPDA-A.

Loss of Communications

1. Check all Audio cable connections to include PTT buttons to insure they are seeded and not depressed by equipment.
2. Check volume settings on the PDA and in the "Symphone" application.
3. Check "Symphone" application to insure correct "Talk Group."
4. Determine correct orientation of radio antenna, and insure radio switch is in the "ON" position.
5. Go to "Tools" menu, select "Find Others" and list soldiers to determine if your PDA is reporting to the network.

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ADVANCED SOLDIER C2 CAPABILITIES

TROUBLE SHOOTING

Loss of ICONS or GPS

1. Select "Tools" menu and select "GPS Status" to determine satellite connectivity.
2. Check to insure the GPS node on the Battery Box Housing is not obstructed by equipment or overhead cover, and is oriented for best connectivity.
3. Insure Radio cable is connected to the GPS Battery Box Housing.
4. Turn off PDA, Turn off radio, remove battery from GPS/ Battery Box Housing. Check battery life.
5. Re-insert battery into GPS/ Battery Box Housing and secure, turn radio power switch to "ON," and initiate PDA by pushing soft "RESET."
6. Enter correct organizational data and initialize RPDA-A; insure correct mapping image is posted.
7. Wait for GPS to acquire, select "Tools" menu, select "Find Others" and "List Soldiers" to insure your radio is reporting to the network.

E*x*

Slide 2

ADVANCED SOLDIER C2 CAPABILITIES

TROUBLE SHOOTING

PDA Backlighting

1. In the event the RPDA-A PDA screen is too bright or too dim perform the following steps:
2. Select "Settings" from the main pull-down menu in the upper left corner of the PDA screen.
3. Select "System" at the bottom of the PDA screen, and choose the "Backlight" ICON.
4. With your stylus, slide the indicator bar to the desired level of lighting and select "OK" in the upper right corner of the PDA.

Loss of Sound

1. Check all Audio cable connections to include PTT buttons to insure they are seeded and not depressed by equipment.
2. Check the headset connectors for proper connection.
3. Select "Speaker" ICON in the top of the PDA screen and determine level of volume required.
4. Push the large button in the lower right corner of the PDA and the "Symphone" application will appear.
5. With the stylus, slide the volume control to the right to increase volume, to the left to decrease volume.

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Slide 3

ADVANCED SOLDIER C2 CAPABILITIES

START UP "RPDA-A"

NOTE: Press soft "RESET" to clear RPDA-A memory prior to each use. This will automatically start the PDA.

1. Press the "POWER" button firmly in the upper right corner of the soldier PDA for normal operations.
2. The PDA should initiate and give you a "Symphone" screen.
3. With your stylus touch the "X" in the upper right corner and you will see the "RPDA-A" start-up screen.
4. With the stylus, touch the "Start" ICON in the upper left corner of the PDA. With your stylus, select "RPDA-A" to initiate the RPDA-A program.

Click "X"

RPDA-A Start Menu

NOTE: Position your radio antenna so when the till will be obstructed to last in the best GPS and Communications reception.

Symphone Screen

RPDA-A Start Screen

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ADVANCED SOLDIER C2 CAPABILITIES

START UP "RPDA-B"

1. Power the RPDA-B by pressing the power indicator in the top right-hand corner of the RPDA
2. Close the "GPS Network Settings" screen by single clicking the X on the upper right-hand corner of the screen.
3. On the desktop, double click " My Computer."
4. Double click "Storage."
5. Double click "sql."
6. You will now see a message that says "Already Installed." Chose "OK."
7. A navigation window will appear, chose "OK." This will complete the installation of the SQL Server CE.
8. Click the X in the upper right-hand side of the screen to close my computer.
9. Double click "My Computer" once again and navigate to \Flash.
10. Double click "Symphone," then double click Symphone (a small icon with a lightening bolt through it.
11. Once Symphone starts, the top will read "acquiring group"…wait until the screen reads "group acquired."

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ADVANCED SOLDIER C2 CAPABILITIES

START UP "RPDA-B"

12. Minimize Symphone by single clicking 555-000x on the bottom of the screen. You will now see a small icon lightening bolt in the system tray area.
13. Click the X in the upper right-hand side of the screen to close my computer.
14. Double click "My Computer" once again and navigate to \ Flash.
15. Double click "RPDA-A" then double click RPDA-A with the blue icon to start the application.

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Slide 6

ADVANCED SOLDIER C2 CAPABILITIES

START UP

1. The duty position and unit organization screen will appear.
2. Enter your unit and individual data to change position/ task organization and tap "OK" using the stylus.
3. The RPDA-A application will begin loading and give you the status.
4. Once the application is loaded, a map will appear with your current position indicated on the map in your squad color with the appropriate weapons symbol.
5. To verify your position, move in any direction to insure your ICON is in the correct location.

Duty Position Data

Status of map loading

Map with ICON

E*x*

Slide 1

ADVANCED SOLDIER C2 CAPABILITIES

MENU NAVIGATION

Main Menu

Exit		
Map		
Mail		
Devices ▶	√ GPS	
	LRF	
Robot ▶	CMU ATV ▶	Waypoints
		Weapons
		Sensors
	iRobot ATV ▶	Weapons
		Sensors
	Packbot ▶	Video
		Weapons
		Sensors
Translator		
Advanced ▶	Soldier Mgr	
	Msg Mgr	
	Map Mgr	
Menu		

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Slide 2

ADVANCED SOLDIER C2 CAPABILITIES

MENU NAVIGATION

Tools			Mail	
GPS Status			Incoming	
			Outgoing	
Record Mission			Back to Map	
System Diagnosis ▶	Manual GPS		**Mail**	
	Record Events			
Find Others ▶	List Soldiers			
	View Tree			
About				
Tools				

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ADVANCED SOLDIER C2 CAPABILITIES

MENU NAVIGATION

Map

Load New Map		
Calibrate Map		
Find Me		
√ Stay On Me		
√ ICON Labels		
Filter ICONs ▶	By Leaders ▶	Platoon Ldrs
		Squad Ldrs
		Team Ldrs
	By Group ▶	My Platoon
		My Squad
		My Team
	√ Show All	
Mark Target		
Overlay ▶	Draw Waypoint	
	Draw Path	
Show Connectivity ▶	All Radios	
	My Radio	
	None	
Map		

Map (Quick Menu)

Show Coord
Mark Target
Mark Waypoint
Hide Menu

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ADVANCED SOLDIER C2 CAPABILITIES

ORGANIZATIONAL

1. Display "List of Soldiers." This function allows you to see the task organization of your unit and who is operating on your network.
2. Select "Tools," "View Tree," and specific soldier; the map will "Auto Center" on that soldier.
3. Select "Tools" and "Find Others" and the display will show who is currently operating on the network.

View Tree   Find Others

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ADVANCED SOLDIER C2 CAPABILITIES

Mapping Data

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ADVANCED SOLDIER C2 CAPABILITIES

MAPPING DATA

1. GPS LEGEND

UNIT	COLOR
SELF	RED
1st SQD	PURPLE
2nd SQD	LT. RED
3rd SQD	GREEN
ROBOTS	YELLOW
BAD GPS REPORTING	GRAY

Scale Bar (Meters)
Ten Digit Grid
Topographic Map/ Scaled Satellite Imagery
Your Position (Type Weapon)
Map Zoom
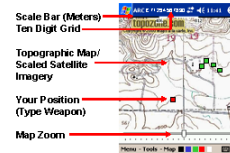
2. Scale Bar at the top is graduated in meters.
3. Ten digit MGRS coordinate is at the top of the screen.
4. Zoom "In" and "Out" at the bottom of the screen.
5. North is always the top of the PDA so orient yourself accordingly.
6. The GPS updates every 5 seconds.

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Slide 1

ADVANCED SOLDIER C2 CAPABILITIES

MAPPING ICONS

Company Commander	Squad Leader Team Leader Rifleman	Robot (Not Armed)
First Sergeant	Automatic Rifleman	Robot (Armed)
Platoon Leader	Crew-served (M240)	MAVRPDA-A (Unmanned Aerial Vehicle)
Platoon Sergeant	Grenadier	Sensors (Various)
Medic Company/ Platoon	MK-19 (40mm)	
Fire Support Officer Fire Support Team	Mortar (Light)	NOTE: Unmanned assets will be identified by a "Yellow" background.

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ADVANCED SOLDIER C2 CAPABILITIES

ICON FUNCTIONS AND OPTIONS

RPDA-A PDA Screen with Situational Understanding

Send Msg
P2P Call
Show Details

PLT LDR
Goldbar Details OK
Name: Goldbar
Rank: 2LT
Duty Pos: PLT LDR
IP Address: 123456789
Latitude: 33.70041
Longitude: 112.091786
Status: Online On GPS

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ADVANCED SOLDIER C2 CAPABILITIES

ICON FUNCTIONS AND OPTIONS

1. With stylus, touch "Send Msg" (Message) and the text messaging program will appear allowing the user to send a text message without having to navigate back through the main menu.

2. With the stylus touch "P2P Call" and the RPDA-A will allow the user to initiate a point to point call. To end the call simply touch "P2P Call" again.

3. With the stylus touch "Show Details" and the RPDA-A will show name, rank, duty position, location, IP address, and status of GPS, and digital radio.

Send Msg
P2P Call
Show Details

PLT LDR
Goldbar Details OK
Name: Goldbar
Rank: 2LT
Duty Pos: PLT LDR
IP Address: 123456789
Latitude: 33.70041
Longitude: 112.091786
Status: Online On GPS

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ADVANCED SOLDIER C2 CAPABILITIES

MAPPING DATA

7. Select "Map" and "GPS Status;" this screen will give you time since last GPS update, number of satellites currently tracking your position, ground speed, elevation, ZULU time, position in MGRS, and position in LAT/ LOG.

MAP CALIBRATION

1. Find a well defined location on the map and preposition yourself there.
2. Refine your position by using the "Zoom" bar at the bottom of the Screen.
3. Select "Map" and select "Start Calibration" and you will be prompted with instructions.
4. Follow the instructions step-by-step.

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ADVANCED SOLDIER C2 CAPABILITIES

MAP CALIBRATION

5. With your stylus, touch the designated location on the map.
   NOTE: Be very precise in designating your new location.
6. The RPDA-A will prompt you to restart the system.
7. Select "Menu" at the bottom of the screen, and select "Exit."
8. Select the "Start" ICON at the top of the PDA, select "RPDA-A" to restart the system. Once restarted follow the start procedures and continue operations.

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ADVANCED SOLDIER C2 CAPABILITIES

Text Messaging and Ancillary Features

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ADVANCED SOLDIER C2 CAPABILITIES

TEXT MESSAGING

Pre-Formatted Messaging
Text Messaging
Incoming/ Outgoing Mail

Outgoing
1. Select "Menu" and "Outgoing."
2. Select "Keyboard" and begin typing message.
   Un-select keyboard when typing is completed.
3. Select the "TO" pull down menu and you will
   be prompted with active addresses.
4. Select address of the intended recipient and
   select "Send" at the bottom of your screen.

Incoming
1. Select "Menu" and "Incoming."
2. Select the specific message and read.
3. To reply select "Reply" or "Forward."

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ADVANCED SOLDIER C2 CAPABILITIES

POCKET TERP

Translator

1. Arabic and Pashtu Phrase Translators.
2. Iraq and Kandahar's "Most Wanted."
3. Mine Awareness.

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ADVANCED SOLDIER C2 CAPABILITIES

POCKET TERP FEATURES

• Select Menu and Internet Explorer.

• Select language (Pashtu or Arabic).

• With the "Stylus" tap Village Greetings (a list of standard phrases
  should appear).

• Select a specific phrase.

• Tap "PLAY" with the Stylus to listen to the language translation.

• Tap blue "Back Arrow" at bottom of screen to return to previous
  list).

• Tap "Home" ICON to go to Soldier Information.

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ADVANCED SOLDIER C2 CAPABILITIES

SUMMARY

HISTORICAL BACKGROUND
TRAINING OBJECTIVES
DESCRIPTION
RPDA-AHITECTURE
SOFTWARE FAMILIARIZATION
SYSTEM START UP
RPDA-A FUNCTIONS
PRACTICAL APPLICATION
REVIEW/ AAR

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QUESTIONS?

2. RPDA-B STARTUP INSTRUCTIONS

1. Press power button.
2. "GPS Network Settings" – Tap [OK].
3. Tap [Stop GPS].
4. (Double tap to open/activate icons, like a double-click in Windows): Calibrate > [Calibrate] > ignore arrow on screen, line up stylus tip with target.
5. Repeat Step 4 until satisfied, close Calibrate app.
6. My Computer > Flash *(folder)* > ARC *(folder)* > ARC *(application).*
7. Click [Ok] on the three (or more) error message boxes.
8. Use ARC program as with RPDA-A: set Manual GPS.
9. NOTE: Using Menu > Mail to chat will crash the device.
10. For Chat: Start Menu > Text Chat.
11. Tap in text area, call up keyboard (icon in lower right). Tap send.
12. Close Chat window when done.
13. To shut down or restart RPDA, use Start Menu > Suspend.

3.   RPDA-C LESSON PLAN BRIEF

Note: additional teaching notes can be found in the "presenter's notes" in the original Powerpoint files.

Basic RPDA Functions (RPDA C)

Instructor

Lesson Plan

- Overview of device C
- Messaging
  - Send message
  - Receive message
  - Recall old messages
- Mapping
  - Locate own position
  - Determine bearing and range to point
  - Orient on map features

Overview

- Only a small portion of full features will be covered
- Power On, Off (leave ON)
- Screen, stylus
- Tap, double-tap (stylus)
- Short push, long push (buttons)
- Virtual Keyboard
- Main applications: ArcPad and Text Chat
  - ArcPad: Short push on "4" button to launch
  - Text Chat: Long push on "2" button to launch
- Look for "X" button in upper right corner to close windows
- It will not be necessary to use other applications on the RPDA

Messaging

- Hold down "2" button until Text Chat window appears
  - If "2" button is pushed too briefly, a different application will open. Close this application using the "X"
- Launch virtual keyboard with a firm tap on the stylus icon (2nd from right in bottom taskbar)
- Tap in the white area of the Text Chat window to see the blinking cursor and then use virtual keyboard to enter message by tapping firmly on letters
- Tap Send

Messaging

- Scroll through gray area in Text Chat window to read previous messages (both sent and received)
- Can scroll and move windows
- DO NOT hit the "X" box on the Text Chat window when switching to another application; leave it open. Doing otherwise will erase your message log and undermine your ability to receive messages
- To close the virtual keyboard, firmly tap on the keyboard icon (2nd from right in bottom taskbar)

Mapping

- Short Push on the "4" button will start ArcPad application
- Relevant Menus are:
  - 2nd Row, 4th from left: Measure, Advanced Select (bearing, range, and grid coordinates)
  - 2nd Row, 1st on left: Zoom In, Zoom Out, Pan

Grid Coordinates

- Advanced Select (6th in appropriate pull down menu)
- Tap on the desired point.
- In the resulting Feature Information box, tap the "+" next to XY Coordinates.
- Scroll down to the bottom for MGRS coordinates.

Bearing and Range

- Select Measure from the appropriate pull down menu (2nd).
- Tap on each of the two points using the presented ruler icon. This should create a solid red line between the two points.
- Tap on Measure again (in the taskbar) to bring up the Measurement Information window and find the bearing and range (From -> To and Distance) of the trip.

Zooming and Panning

- Be sure to select the "Pan" feature before trying to scroll around or tap on map
- To zoom in or out, select the appropriate feature and tap on the desired center of the zoomed image
- Be patient when using these applications

Practical Application - Messaging

- Start Text Chat, open Arcpad, return to Text Chat
- Send a comm check
- Send three and receive three text messages
- Recall the first message you sent (using the message log).

Practical Application - Mapping

- Open/Return to ArcPad
- Find the grid coordinate of a specific point.
- Use zoom and pan to find various points.
- Find the bearing and range from one point to another.

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4. RPDA-D LESSON PLAN BRIEF

Lesson Plan

- Overview of device D
- Messaging
  - Send message
  - Receive message
  - Recall old messages
- Mapping
  - Locate own position
  - Determine bearing and range to point
  - Orient on map features

Overview

- Only a small portion of full features will be covered
- Power On, Off (leave ON)
- Screen, stylus
- Tap, tap and hold, double-tap
- Virtual Keyboard
- Main application: C2CE
  - Start-> C2CE (if necessary)
- Look for "OK" button in upper right corner to close windows
- DO NOT attempt to use other applications on the RPDA

Messaging

- Start in C2CE Main Window
- Tap handset icon (4th from left)
- Tap radio with green check for "Comm Check"
- Tap in Composer area (so that cursor blinks there)
- Use virtual keyboard to enter message
- Tap Send All (envelope All) icon
- Scroll through Communications Log area to read previous messages
- Tap OK (in upper-right corner) to close

Message Log

- Start in C2CE Main Window.
- Tap Yellow Pad icon (5th from left)
- You can display, all messages, only Transmitted (TX), or only Received (RX).
- List shows time sent or received.
- Select message and tap View.
- Tap Tx to transmit selected message again.
- Can scroll and adjust column widths.

199

Mapping

- Start in C2CE main screen
- Icons are (left to right):
  - Pointer: display grid of the location you tap
  - Range Bearing: from/to two points on map
  - Draw (ignore)
  - Route: create waypoints in a route
  - Pan: tap and drag to move the map around
  - Zoom In (+), Out (-), Zoom Box

Routes

- Tap Route icon (R).
- Tap points along route.
- Tap Pointer (arrow) when done.
- Tap Rts menu (at bottom of screen), select Rts Mgr
- Select the QuickRoute you just created (highest number)
- Tap Edit
- Use Scroll bar and/or adjust column width to see the position of each waypoint on the route
- "Course" column shows the bearing from this waypoint to the next, "Leg Length" shows the distance.
- "Total" column shows the total distance up to that waypoint.

Practical Application - Messaging

- Start C2CE, close C2CE, start it again
- Send a comm check.
- Send three and receive three text messages.
- Recall the first message you sent (using the message log), and record the time it was sent. Send it again.

Practical Application - Mapping

- Find the grid coordinate of a specific point.
- Use zoom and pan to find various points.
- Find the bearing and range from one point to another.
- Create a route with at least three legs.
- Identify the bearing and distance of the first leg.
- Find the total distance of your route.

5.   RPDA AND BASIC LAND NAVIGATION PRACTICAL APPLICATION

Perform each task using both conventional means (i.e. paper map and protractor) and using the RPDA. Write down notes on how to do each task, and bring this sheet with you to the testing.

☐ Start RPDA main application, close it, start it again.

☐ Send communications check

With a partner:

☐ Send three and receive three text messages.

☐ Recall the first message you sent, and record the time it was sent: _____

☐ Send the first message you sent again.

☐ Find the grid coordinate of a specific point, use zoom and pan to find various points (choose two):

Carmel River State Beach	
Asilomar State Beach	
Monterey Airport	
Salinas Airport	
Moss Landing	

☐ Find the bearing and range from the two points you found above.

Bearing:_____   Distance:_____

☐ Create a route with at least three legs.

☐ Identify the bearing and distance of the first leg.

Bearing:_____   Distance:_____

☐ Find the total distance of your route.

Total Distance: _____

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APPENDIX H.   INFORMATION FOR PARTICIPANTS

1.   RESEARCH BRIEF

Human Factors Study of Ruggedized Personal Digital Assistants (RPDAs)

Capt Takagi, USMC
Lt Read, USAF
Lt Simpson, USAF

Introduction

- What this study is (and is not)
- What we will do today
- What we will do later this week
- Admin details

What is this study for?

- Testing four Ruggedized Personal Digital Assistants (RPDAs) in use or being considered by US Army Special Operations Command (USASOC) and USMC units in Iraq and Afghanistan.
- We are primarily testing the "user-friendliness" of the software (not the hardware, networking, etc.)
- We are not the developers, and are not advocates of any particular system.
- There are significant limits to what we are studying, but we will report all comments on to the program managers.

What is this study for?

- Why so few devices?
  - Most are committed to operational forces.
- Why does _____ seem broken?
  - These are prototype units.
- Will I ever use one of these?
  - It's quite possible. For example, there are variations specialized for translation.

Today

- 2-3 hour training session on a single Ruggedized Personal Digital Assistant (RPDA).
- Review of similar tasks in the "traditional" method (radios, paper maps).
- Schedule testing sessions for later this week.

Later this week…

- Each participant will come to NPS to operate the RPDA for a single 1-2 hour individual session, which will be videotaped.
- Will schedule small groups at one time (prefer 2-6 individuals).
- Lab is available 0700-0900 and 1000-1800 Wed and Thu, and 0700-1900 Friday.

Admin

- Any questions about your packet?
  - Keep these:
    - Participant Information Form
    - Card with your Participant ID#
  - Turn in *when you come to NPS* (not today)
    - Three consent forms (signed)
    - Participant ID form ("For Official Use Only")
    - Technology Experience Survey

Privacy and Safety

- Your name will not be used anywhere in the study or the final report.
- Please speak freely so that your feedback can be used to improve the devices.
- If you choose not to participate, simply let your NCOs know. I will not know who did or did not participate in the study.
- During this study, there should be no more risk to you than you are exposed to in your current daily routine. Please inform any researcher if you see any unsafe conditions.

2. LETTER TO REQUEST PARTICIPANTS

Applied Warfighter Ergonomics / Human Systems Integration
Department of Operations Research Naval Postgraduate School
Glasgow Hall rm 221
lab phone: (831) 656-3134

I am a graduate student conducting Human Factors research at the Naval Postgraduate School. We are seeking participants in equipment testing. Specifically, we are testing ruggedized personal digital assistants (RPDAs - basically handheld networked tactical computers) for the Special Operations Command (SOCOM). Some of the devices are in current use by SOCOM in Iraq and Afghanistan.

We are seeking DLI students, available between now and mid-August, to participate in this important, real-world testing. They would definitely benefit from exposure to state-of-the-art equipment that is already filtering down from SOCOM to regular units, and by participating in the tactical scenarios (based on current operations in Iraq and elsewhere) that we are developing.

Our testing would involve:
1.   Approximately two hours of training on the equipment in a group session.
2.   Approximately one hour per individual to observe the students, one at a time, using the equipment in simulated tactical scenarios.

Ideally, participants would be military personnel with very basic training in tactical procedures, such as wearing body armor, reading a map, and talking on a radio. The training any Marine or Soldier receives in boot camp would be sufficient. Personnel from other services, and even civilians (including those who have never been exposed to any tactical training) would also be welcome. Participants should not be "specially selected" on the basis of being more or less proficient than others - the equipment, not the participants, is being tested. The participants should be representative of all possible users, skilled and less skilled.

To be a rigorous test, we would like to have twenty to forty individuals, who would be available as described above. Each individual participant would only have to be available for the initial half-day training in small groups, and then for a few hours sometime in the next week or so. Since each participant must be observed and recorded individually, it will take several days to work through all the participants, one at a time.

We are very flexible about when and how this could occur, between now and maybe mid-August. We could also do this as a series of smaller groups (as few as four to ten individuals, in several blocks over the period), if that would be easier to schedule.

The attachment describes our laboratory equipment. I would be happy to demonstrate our laboratory, or brief this experiment, to anyone who may be interested in more information. I can best be contacted via email: ktakagi@nps.edu.

Very Respectfully,
Koichi Takagi
Capt USMC

email: ktakagi@nps.edu
home: (831) 372-5912

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3.   PARTICIPANT INFORMATION FORM

PARTICIPANT INFORMATION FORM

To all research study participants:

You are invited to participate in a research study at the Naval Postgraduate School. Your participation will help improve equipment currently in use by Special Forces in Iraq and Afghanistan. Please read the description of the research on the following three pages, and initial and sign where requested.

This is not a test of your skills or abilities. I want to emphasize that your participation or non-participation in this study will have no effect on your current or future military status. The *equipment*, not the individual participants, is being evaluated. There is no question of you, the participant, doing "well," or "poorly," and neither your participation nor your individual results will be entered into your military record, or released to your current command.

Please do not discuss any part of the study with other students, or potential participants, until the study has concluded (around September, 2005). We want all participants to be equally prepared during the study, and no-one to be "coached" or otherwise prepped beforehand.

During the study, you will receive approximately two to four hours of training (as a group) on a piece of military equipment. Please do your best to learn the gear, and ask as many questions as you like of the instructors or researchers. Within a few days after the training, you will be brought to the Naval Postgraduate School for an individual session of less than two hours. You will operate the equipment you were trained on while wearing body armor, helmet, etc., and watching a tactical scenario on a large plasma-screen TV. Many portions of the study will be videotaped, and so there is a release form that we ask you to sign so that we may use the recordings. These standard consent forms are always required in any kind of research on people. I do not believe there is the slightest risk to your health or to your privacy.

Please fill out the enclosed survey. If you have any questions about the survey, we will answer them during the group training session.

Please don't hesitate to ask us any questions you may have at any time during the study. Thank you for your participation.

Sincerely,

Capt Koichi Takagi
United States Marine Corps

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4.   CONSENT FORMS

PRIVACY ACT STATMENT

NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA 93943
PRIVACY ACT STATEMENT

1. Purpose: Data from this research, *Evaluating the Human Factors of Military Handheld Computing Devices*, will be used to develop tests, tactics, procedures, and equipment to improve the human-machine interfaces of military handheld computing devices.

2. Use: Research data from this study will be used for statistical analysis by the Departments of the Navy and Defense, and other U.S. Government agencies, provided this use is compatible with the purpose for which the information was collected. Use of the information may be granted to legitimate non-government agencies or individuals by the Naval Postgraduate School in accordance with the provisions of the Freedom of Information Act.

3. Disclosure/Confidentiality:

   a. I have been assured that my privacy will be safeguarded. I will be assigned a control or code number which thereafter will be the only identifying entry on any of the research records. The Principal Investigator will maintain the cross-reference between name and control number. It will be decoded only when beneficial to me or if some circumstances, which is not apparent at this time, would make it clear that decoding would enhance the value of the research data. In all cases, the provisions of the Privacy Act Statement will be honored.

   b. I understand that a record of the information contained in this Consent Statement or derived from the experiment described herein will be retained permanently at the Naval Postgraduate School or by higher authority. I voluntarily agree to its disclosure to agencies or individuals indicated in paragraph 3 and I have been informed that failure to agree to such disclosure may negate the purpose for which the experiment was conducted.

   c. I also understand that disclosure of the requested information, including my Social Security Number, is voluntary.

Name, Rank (please print)	
Signature of Voluntary Participant	**Date**

PARTICIPANT CONSENT FORM

1. Initial:_____ **Introduction.** You are invited to participate in a study of military handheld computing devices. With information gathered from you and other participants, we hope to discover the human factors considerations pertaining to these devices. Please read and sign this form indicating that you agree to be in the study. Feel free to ask any questions you may have before signing.

2. Initial:_____ **Background Information.** The Naval Postgraduate School Human System Integration Laboratory and Applied Warfighter Ergonomics Center are conducting this study.

3. Initial:_____ **Procedures.** If you agree to participate in this study, the researcher will explain the tasks in detail. There will be several sessions consisting of written questionnaires, equipment training and operation, and participation in multimedia tactical scenarios.

4. Initial:_____ **Risks and Benefits.** This research involves no risks or discomforts other than: answering questions (on paper and in person) about your experiences with various equipment during field exercises and/or laboratory trials. You may be asked to wear standard military individual equipment. Audio and video recordings of your participation will be made if you consent (item 9 below). Your participation will significantly contribute to improving the effectiveness of equipment currently being fielded in the U.S. Dept. of Defense and to current research in human-machine interaction.

5. Initial:_____ **Compensation.** No tangible reward will be given. A copy of the results will be available to you at the conclusion of the experiment.

6. Initial:_____ **Confidentiality.** The records of this study will be kept confidential. Special care will be taken to preserve anonymity in all data collection. Written documentation will be identified by participant number only. No information which could identify you as a participant will be made accessible to your military unit, your supervisors, or to the public.

7. Initial:_____ **Voluntary Nature of the Study.** If you agree to participate, you are free to withdraw from the study at any time without prejudice. You will be provided a copy of this form for your records.

8. Initial:_____ **Points of Contact.** If you have any further questions or comments after the completion of the study, you may contact the principal researcher, Nita Lewis Miller, PhD, at (831) 656-2281, DSN: 756-2281, nlmiller@nps.edu, or Capt Koichi Takagi, USMC, at (831) 656-3134, ktakagi@nps.edu.

9. Initial:_____ **Consent to Video and Audio Recording.** I agree that audio and video recordings of my participation in this research may be made. I agree that the recordings may be:
   Initial:_____ Studied by members of the research team,
   Initial:_____ Shown to other researchers, research participants, and students, and
   Initial:_____ Used in future training.

10. Initial:_____ **Statement of Consent.** I have read the above information. Any questions I had concerning this research have been answered to my satisfaction. I agree to participate in this study.

Signature of Researcher	Date
Nita Lewis Miller	15 July 2005
Signature of Voluntary Participant	**Date**

MINIMAL RISK CONSENT STATEMENT
NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA 93943

Participant: VOLUNTARY CONSENT TO BE A RESEARCH PARTICIPANT IN: Evaluating the Human Factors of Military Handheld Computing Devices

1. I have read, understand and been provided "Information for Participants" and "Participant Consent Form" that provides the details of the below acknowledgments.

2. I understand that this project involves research. An explanation of the purposes of the research, a description of procedures to be used, identification of experimental procedures, and the extended duration of my participation have been provided to me.

3. I understand that this project involves only minimal risk. I have been informed of any reasonably foreseeable risks or discomforts to me.

4. I have been informed of any benefits to me or to others that may reasonably be expected from the research.

5. I have signed a statement describing the extent to which confidentiality of records identifying me will be maintained.

6. I have been informed of any compensation and/or medical treatments available if injury occurs and is so, what they consist of, or where further information may be obtained.

7. I understand that my participation in this project is voluntary, refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled. I also understand that I may discontinue participation at any time without penalty or loss of benefits to which I am otherwise entitled.

8. I understand that the individual to contact should I need answers to pertinent questions about the research is Professor Nita L. Miller, Principal Investigator, and about my rights as a research participant or concerning a research related injury is Prof. Jim Eagle, Operations Research Dept. Chairman or LTC Eric Morgan, MC, USA, Commanding Officer of the Presidio of Monterey Health Clinic. A full and responsive discussion of the elements of this project and my consent has taken place. NPS Medical Monitor: LTC Eric Morgan, MC, USA, eric.morgan@nw.amedd.army.mil, (831) 242-7550, doctor on-call pager: (831) 648-2177.

Signature of Researcher	Date
Nita Lewis Miller	July 15, 2005
Signature of Voluntary Participant	Date

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5.   MAPS TO NPS

- **Enter the 10th St and Sloat gate**
- **Follow perimeter road: Morse Rd. turns into Lake Del Monte, turns into Cunningham Rd.**
- **Turn Right on Bouldry Road and look for parking. Parking is very difficult on NPS – allow 15 min. just to find a space!**
- **Lab is in Glasgow Hall rm 221, ph 656-3134.**
- **Capt Takagi cell phone 236-6306.**
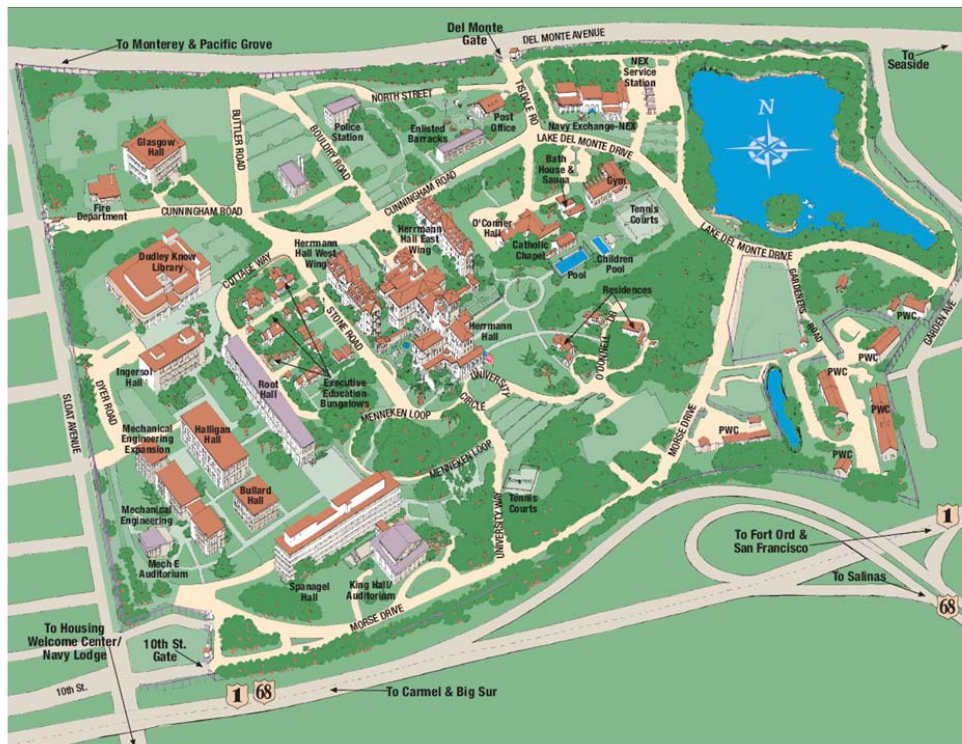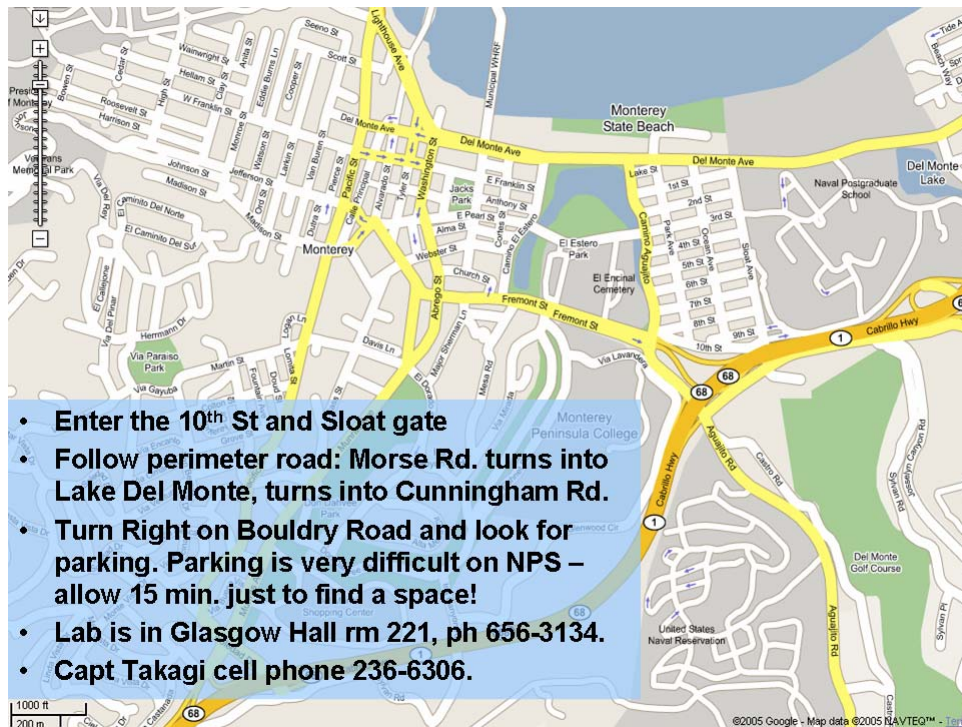
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6.   PARTICIPANT ID FORM AND ID CARDS

Participant ID #	
Date	

Please keep your participant ID # with you at all times until the conclusion of the study.

The information below will be used only if there is a need to contact you after the conclusion of this study. Special care will be taken to preserve anonymity during all data collection and analysis. Any comments or opinions you express during this study will not be attributed to you in any manner. Written documentation will be identified by your Participant ID number only, and faces and voices will be obscured on video recordings when possible. No information which could identify you as a participant will be made accessible to your military unit, your supervisors, or to the public without your consent.

Last name	
First name, middle initial	
Rank	
Branch of service	
Unit or organization POC information *please give a mailing address, and phone number that we could use to contact you in the future, if necessary*	
email address	

Research Participant

Naval Postgraduate School
Applied Warfighter Ergonomics
Glasgow Hall room 221
(831) 656-3134

Participant ID#

Research Participant

Naval Postgraduate School
Applied Warfighter Ergonomics
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(831) 656-3134

Participant ID#

Research Participant

Naval Postgraduate School
Applied Warfighter Ergonomics
Glasgow Hall room 221
(831) 656-3134

Participant ID#

APPENDIX I. INSTITUTIONAL REVIEW BOARD FORMS

Nita Lewis Miller, Ph.D.
Operations Research Department
Glasgow Hall
Naval Postgraduate School
Monterey, California 93943

831-656-2281
DSN: 756-2281
Fax: 831-656-2595
nlmiller@nps.navy.mil
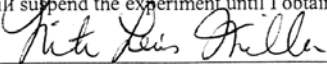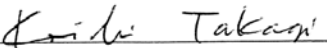
To: Protection of Human Subjects Committee

Subject: Application for Human Subjects Review for <u>Evaluating the Human Factors of Military Handheld Computing Devices</u>

1. Attached is a set of documents outlining surveys, direct observation and recording, interviews, after-action reports, and focus group studies to be conducted over the next year. Some studies will be conducted in conjunction with the Tactical Network Topology (TNT) project at NPS, Inter-4 Corporation of San Francisco, California, Exponent Corporation of Menlo Park, California, the United States Army Special Operations Command (USASOC), and the United States Marine Corps.

2. We are requesting approval of the described experimental protocol. An experimental outline is included for your reference that describes the methods and measures we plan to use.

3. We include the consent forms, privacy act statements, all materials and forms that a subject will read or fill-out, and the debriefing forms (if applicable) we will be using in the experiment.

4. We understand that any modifications to the protocol or instruments/measures will require submission of updated IRB paperwork and possible re-review. Similarly, we understand that any untoward event or injury that involves a research participant will be reported immediately to the IRB Chair and NPS Dean of Research.

Nita Lewis Miller
Nita Lewis Miller, PhD

Koichi Takagi
Koichi Takagi, Capt USMC

APPLICATION FOR HUMAN SUBJECTS REVIEW (HSR)	HSR NUMBER *(to be assigned)*

PRINCIPAL INVESTIGATOR(S) *(Full Name, Code, Telephone)*
Nita Lewis Miller, Ph.D., **CODE 61** 831-656-2281 DSN: 756-2281 Fax: 831-656-2595
Koichi Takagi, Capt, USMC, CODE 61 831-656-2281 DSN: 756-2281 Fax: 831-656-2595

APPROVAL REQUESTED   [X] New   [ ] Renewal

LEVEL OF RISK   [ ] Exempt   [X] Minimal   [ ] More than Minimal
Justification:

WORK WILL BE DONE IN (Site/Bldg/Rm) Glasgow 221, Camp Roberts, California, Fort Ord, California, and other field locations	ESTIMATED NUMBER OF DAYS TO COMPLETE 180 days
MAXIMUM NUMBER OF SUBJECTS 100	ESTIMATED LENGTH OF EACH SUBJECT'S PARTICIPATION est. total 6 hrs, 2-4 hrs per day, in a 2 week period

SPECIAL POPULATIONS THAT WILL BE USED AS SUBJECTS
[ ] Subordinates   [ ] Minors   [X] NPS Students   [ ] Special Needs (e.g. Pregnant women)
Specify safeguards to avoid undue influence and protect subject's rights:
Special care will be taken to preserve anonymity in all data collection. Written documentation will be identified by number only, and faces and voices may be obscured on video recordings.

OUTSIDE COOPERATING INVESTIGATORS AND AGENCIES
Tactical Network Topology (TNT) project at NPS, Inter-4 Corporation of San Francisco, California, Exponent Corporation of Menlo Park, California, the United States Army Special Operations Command (USASOC), and the United States Marine Corps.

TITLE OF EXPERIMENT AND DESCRIPTION OF RESEARCH (attach additional sheet if needed).
Army Rangers, Special Forces team members, and other DoD enlisted members and officers, will be field testing new handheld computers (including Inter-4's Tacticomps, NavBoards and Exponent ARC PDAs) and the Tactical Network Topology (TNT) system. Other handheld systems may be tested in similar environments, as available. A short pre-exercise will be given to assess each participant's familiarity and comfort in using current technology. During- and post-exercise surveys, interviews, and focus groups will assess the performance and usability of the equipment. Participants' interactions with the equipment may be recorded (audio and video) during field exercises and in laboratory settings, and detailed records (behavioral coding) made of their activities and reactions. The usability of military handheld electronic devices, and the factors influencing the acceptance and adoption of those devices, will be analyzed as a product of this research.

I have read and understand NPS Notice on the Protection of Human Subjects. If there are any changes in any of the above information or any changes to the attached Protocol, Consent Form, or Debriefing Statement, I will suspend the experiment until I obtain new Committee approval.

SIGNATURE _Nita Lewis Miller_   DATE _15 July 2005_

SIGNATURE _Koichi Takagi_   DATE _15 JUL 05_

APPENDIX J.   SOFTWARE AND HARDWARE CONFIGURATION

1.   **NOLDUS "THE OBSERVER" SOFTWARE**

Observation files were named using this convention:

R __   __ __ __ __   __ __

The first letter after "R" is the device tested, either A-D for the RPDAs, or Z for the conventional equipment.

The next four digits are the participant's ID, in the range 0500-0599 for this study.

The last two character's are the coder's initials, either "KT" for Koichi Takagi or "KB" for Katie Buettner.

2. X-KEYS MACRO KEYBOARD

In addition to the key assignments shown below, the jog dial (inner spinning wheel) was set to FFWD (jog right) and REW (jog left).
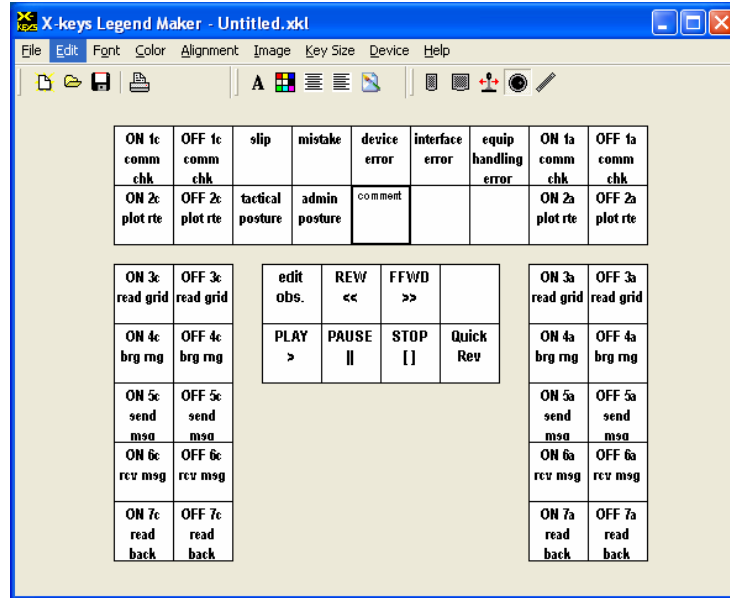
X-keys Macro Maker - Takagi RPDA study conf.xk4   Editor, Green layer

Key Type Comment	Key Type Comment	Key Type Comment
0 Macro edit obs.	30 Macro OFF 2c plot rte	60 Macro
1 Macro << REW	31 Macro tactical	61 Macro -4x
2 Macro FFWD >>	32 Macro admin	62 Macro -2x
3 Empty	33 Macro comment	63 Macro -1x
4 Macro PLAY >	34 Empty	64 Macro -1/2x
5 Macro PAUSE	35 Empty	65 Macro -1/5x
6 Macro STOP	36 Macro ON 2a plot rte	66 Macro -1/25x
7 Macro Quick Rev	37 Macro OFF 2a plot rte	67 Empty
8 Empty	38 Macro ON 3c read grid	68 Macro 1/25x
9 Empty	39 Macro OFF 3c read grid	69 Macro 1/5
10 Empty	40 Macro ON 4c brg rng	70 Macro 1/2
11 Empty	41 Macro OFF 4c brg rng	71 Macro 1x
12 Empty	42 Macro ON 5c send msg	72 Macro 2x
13 Empty	43 Macro OFF 5c send msg	73 Macro 4x
14 Empty	44 Macro ON 6c rcv msg	74 Macro FFWD
15 Empty	45 Macro OFF 6c rcv msg	75 Macro Play
16 Empty	46 Macro ON 7c read back	76 Macro
17 Empty	47 Macro OFF 7c read back	77 Macro
18 Empty	48 Macro ON 3a read grid	78 Macro
19 Empty	49 Macro OFF 3a read grid	79 Macro
20 Macro ON 1c comm chk	50 Macro ON 4a brg rng	80 Macro
21 Macro OFF 1c comm chk	51 Macro OFF 4a brg rng	82 Empty
22 Macro slip	52 Macro ON 5a send msg	83 Macro Still
23 Macro mistake	53 Macro OFF 5a send msg	84 Macro
24 Macro device error	54 Macro ON 6a rcv msg	85 Macro
25 Macro interface error	55 Macro OFF 6a rcv msg	86 Macro
26 Macro equipment handling error	56 Macro ON 7a read back	87 Macro
27 Macro ON 1a comm chk	57 Macro OFF 7a read back	88 Macro
28 Macro OFF 1a comm chk	58 Macro FFWD	89 Macro Play
29 Macro ON 2c plot rte	59 Macro RWD	

APPENDIX K.   DATA

1.   FOCUS GROUP NOTES

RPDA Focus Group

Ad-hoc, non-attributional military RPDA Focus Group conducted 1600 – 1730 on 22 Feb 2005 at Camp Roberts, CA. Facilitator: Captain Koichi Takagi, USMC, student researcher at the Naval Postgraduate School

Participants:

Three senior Special Forces staff NCOs participating in a military PDA evaluation exercise.

One representative from USASOC program office (but not the Mobile Access Infrastructure program office responsible for military PDAs).

One employee of an RPDA development company.

Purpose: to determine possible requirements and capabilities for handheld military computing devices (military PDAs). A "brainstorming" environment during the focus group was sought. Ideas were encouraged regardless of current feasibility or real applicability. The following is a list of topics discussed, including: possible operational requirements for military PDAs, general and specific functionality that military PDAs might have, possible uses for and tactical employment of military PDAs, and random comments. Some participants had not used military or civilian PDAs to any great extent, some were unfamiliar with the military tasks discussed. Non-attribution was emphasized, and it was understood that the discussion would not generate obligations by the contractor or the government.

Four critical requirements defined as broad functionality required of a military PDA:

Text messaging, Voice over IP (VOIP) capability, Moving video and still imagery dissemination, and GPS – mapping – situational awareness (SA) – "Blue Force Tracker (BFT)" capability.

Text messaging

ease of input (keyboard, on-screen keyboard, stylus, or other)

speed and accuracy of input are crucial – must test error rate and speed

input must be reliable under a wide range of operating environments (bumpy vehicle, day, night, one handed, etc.)

voice recognition? Again, must be reliable under combat conditions – injury, illness, extreme background noise

cut & paste between messages sent and/or received

word wrap so that whole message is always visible, rather than a scrolling single line

ability to change text size for different conditions (bumpy driving, day, night, etc.)

lexicon of standard military terms and abbreviations

auto-correct and spell check based on above lexicon

auto-complete – this might be bad if it made dangerous errors

recent word history

cues for message received – audio, visual, vibrate? Be able to turn off alerts

message sent confirmation (is network up? Did I do it right?)

delivery confirmation (did they get it?)

keep chat open but minimized

advantage – text chat is 1000 times less bandwidth than voice.

Things we would or could do with text messaging:

- Lists of info to save for later – convoy routes, admin details, fragOs, op order

- Distribution groups for an entire unit

- Add annotation to pictures, describe details

- Flag messages as important for later review / action

- Retrieve past messages, edit and send on to others

How would we do this without a text-messaging military PDA

Other data means – SMEARS? Mini laptop/palmtop VDC card ViaSat

Voice over IP (VOIP)

Important: quality of transmission, reliability, clarity (comparable to current systems)

Full duplex? Don't see need

Record/playback capability

Probably won't replace any current voice radio systems (MBTRs, SINCGARS, etc.) for a long time, so would be an additional piece of gear to carry just for voice comm. Because of this, is VOIP really a pressing need? We will still use many other ways to talk.

Used for:

- Emergency / backup long-range comm, reach-back to higher command
- Flexibility, alternate means
- Collaboration while viewing images (Groove)
- Mobile whiteboard – annotate images, drawings, while talking about it

Video and Still imagery dissemination

Requirements: minimum 5 fps, minimize jitter and data loss

Network needs to be able to provide a minimum of 3 simultaneous video streams (video sources)

Quality is affected by sensor capabilities (color, contrast, zoom)

Current streaming video is "quarter VGA" (QVGA) = 320x240 pixels (similar to VHS tape or broadcast TV)

Would like a local buffer / save capability beyond just streaming so we can playback, rewind, etc.

Search & Rescue "panic button" to show unit what's happening if I go down.

File type compatibility has not been an issue

Different client users involved: dedicated intel analysts (formally school-trained or not), and untrained regular operators. These different users have different expectations and capabilities when given the same image – should test separately.

We can measure things like frame rate, number of pixels, network jitter, etc., but the final measure of success is <u>subjective</u> – can the user *correctly* interpret the video presented?

Mapping, GPS, situational awareness, Blue Force Tracker (BFT)

System should replace BFT, SA tools, MTS

Should completely replace PLGRS

BFT / SA must have restricted lists for SOF teams – not everyone is allowed to see where they are

Mapping – how does interpreting an on-screen, 2inch by 3inch map compare mentally to reading a paper map?

Paper provides far higher resolution (2400dpi+ compared to 72dpi on screen), larger area, quicker and more intuitive manipulation, easier stowage.

Computer capability – have a whole map library in your pocket, from 1:250,000 down to room-by-room blueprints.

Should provide all standard map overlay information like routes, NAIs, RFAs, etc.

Filters for just the units and info I want to know.

Secure comm. critical

Need to have some positive indicator that the units and overlay information shown is reliable or not, is old or new, and how precise it is.

Time of last update shows as a pop-up?

Icons change color as they "age"?

Should map also show when you are off the network, like C2PC

If there is nothing shown on my map, am I missing info, off the net, or is the area truly clear?

Indications of what we know, what we don't know, etc.

Ultimate measure of success: user's ability to understand the info presented and translate it into ground truth.

Everyone looks at a map and a situation differently. Must be able to customize view for each individual operator.

Common iconology

Classic icons used on paper don't always translate well to lo-res screen. Example – checkpoint symbol is usually very hard to see on screen because it's so small. Unit symbols are hard to interpret well. Maybe it's time for new icons for digital maps.

2. SURVEY DATA: INDIVIDUAL COMMENTS

RPDA A - Comments from Handheld Device Evaluations

6. Satisfaction With Text Messages Sent
(501) 4- easy to hit wrong key while typing
(502) 4- keypad letters small, but usable
(506) 4- voice recognition or a small keypad would make entries easier than with the stylus; transmission was easy to effect

8. Satisfaction With Text Messages Received
(502) 5- would prefer notification when message received
(506) 5- easy to read

17. Satisfaction With Mapping Functions
(501) 3- finding labeled places was easy, but finding other locations was hard
(502) 4- easy to view self and others; some symbols hard to interpret (road, airport)
(506) 2- small screen made it difficult to orient self quickly

18. Satisfaction With SA Tools
No comments

20. Satisfaction With Stylus
(501) 1- hard to use the stylus to scroll around map
(505) 5- touch keypad small and possible to make mistakes, but overall good feature
(506) 4- stylus ok, but would prefer keypad or number pad like on a cell phone

26. Ability to Use Personal Weapon
(501) 1- do not see how you could operate M16 and RPDA
(502) 1- only able to hold weapon with one hand
(505) 2- hard to hold RPDA and maintain good grip on weapon
(506) 2- cumbersome; RPDA's wires got tangled with weapon sling

28. Overall Satisfaction With Reliability
(501) 2- reliable for sending messages, but some issues with stylus navigation of the map
(502) 5- no malfunctions; confident in RPDA's calculations
(506) 5- no errors or malfunctions

30. Overall Satisfaction With System
(501) 2- stylus tricky to use in map mode and RPDA gear bulky and harder to move with

(502) 5- helpful in eliminating human error in calculating brg/rng; text messaging quieter than radio for covert situations
(506) 4- effective communication, but hard to use quickly

31. Impression of Ease of Learning and Use
(502) 5- extremely easy
(506) 5- easy to operate

32. Free Comments
(501) separate backpack and wires make RPDA A less desirable
(502) helpful if equipment manufactured to hold device, so when not in use hands could be free for weapon; clearer resolution on some map features; notification of received message
(505) no big glitches; makes navigation/communication tasks a little easier
(506) more effective if attached to forearm or hand to allow simultaneous weapon handling

RPDA B - Comments from Handheld Device Evaluations

6. Satisfaction With Text Messages Sent
(501) 4- easy to hit wrong key, wasting time
(502) 1- hard to hit correct letters because of irresponsiveness of stylus
(505) 4- had to push down hard with stylus, which led to double typing a letter

8. Satisfaction With Text Messages Received
No comments

17. Satisfaction With Mapping Functions
(501) 2- hard to read names on map
(502) 3- hard to pull up coordinates because of stylus

18. Satisfaction With SA Tools
No comments

20. Satisfaction With Stylus
(501) 4- stylus was fairly capable
(502) 1- horrible responsiveness, cumbersome on every level, especially when using keypad
(505) 4- had to push hard

26. Ability to Use Personal Weapon
(501) 1- could not aim or shoot weapon while operating RPDA, in terms of mechanisms and concentration
(505) 3- hard to operate simultaneously

28. Overall Satisfaction With Reliability
(501) 4- easy to hit wrong key while typing
(502) 1- stylus

30. Overall Satisfaction With System
(501) 4- liked size; liked receive message function and reading old messages, both sent and received
(502) 1- stylus

31. Impression of Ease of Learning and Use
(502) 5- easy to learn

32. Free Comments
(501) hard to type and concentrate on event in the scenario; system better for reconnaissance or sniper mission to quietly give reports/receive orders w/o radio noise; in high speed situations, a radio is preferable; finding grid coordinates, distance, direction, of location in reference to oneself works well, but it would be better if one could also find distance, direction between two points independently of one's own location
(502) too bulky and stylus too difficult to use
(505) only flaw was stylus—pushing down harder made it difficult

RPDA D - Comments from Handheld Device Evaluations

6. Satisfaction With Text Messages Sent
(528) 5- used chat slang for brevity

8. Satisfaction With Text Messages Received
No comments

17. Satisfaction With Mapping Functions
No comments

18. Satisfaction With SA Tools
(528) 4- would like to see current *(?)* data displayed—panic button for key data

20. Satisfaction With Stylus
(528) 4- alternate means if lost? damage to screen potential

26. Ability to Use Personal Weapon
(515) 2- requires weapon to be slung to operate
(527) N/A- M9 or M4 more suited for use with this device
(528) none- difficult w/o a drop capability

28. Overall Satisfaction With Reliability
(527) 4- comms piece came loose at first *(system crashed)*

30. Overall Satisfaction With System
(528) 4- software should be upgraded

31. Impression of Ease of Learning and Use
(528) 5- would use in combat with suggestions made

32. Free Comments
No comments

3. SURVEY DATA: INDIVIDUAL NUMERICAL RESPONSES

	Participant Number	RPDA-D *listed in order tested -->* 0513	0514	0515	0528	0527
TES1	have cell phone (yes/no)	1	1	0	1	0
TES2	talk on phone (hours)	9	5	0	5	0
TES3	use text messaging (hours)	2	2	0	1	0
TES4	customize cell phone (hours)	1	1	0	0.2	0
TES5	play games on cell phone (hours)	1	2	0	0	0
TES6	phone numbers stored in cell phone (#)	40	75	0	100	0
TES7	PDA use	2	2	2	2	1
TES8	PDA stylus use	3	3	3	3	1
TES9	video game play (hours)	7	7	2	0	0
TES10	online video games (yes/no)	0	1	1	0	0
TES11	home computer video games (yes/no)	1	1	1	0	0
TES12	video game system video games (yes/no)	1	1	1	0	0
TES13	list favorite games	*	*	*		*
TES14	has work computer for own use (yes/no)	0	0	0	1	1
TES15	has shared work computer (yes/no)	1	1	0	0	0
TES16	almost never use computer at work (yes/no)	0	0	1	0	0
TES17	use computer in living quarters (yes/no)	1	1	1	1	1
TES18	use public computers (yes/no)	1	0	1	0	0
TES19	use several programs at same time (yes/no)	1	1	1	1	1
TES20.1	computer problem: a. stop	5	5	2	4	5
TES20.2	computer problem: b. read manual	3	3	5	5	4
TES20.3	computer problem: c. read help	2	2	3	3	2
TES20.4	computer problem: d. ask for help	4	4	4	2	3
TES20.5	computer problem: e. keep trying	1	1	1	1	1

	Participant Number	RPDA-D *listed in order tested -->* 0513	0514	0515	0528	0527
TES21	use a computer					
TES22	*use email (hrs per week)	5	200	20	200	100
TES23	*use email attachments (hrs per week)	1	100	2	50	50
TES24	*use online chat or IM (hrs per week)	1	1000	0	0	0
TES25	*use internet to find information (hrs per week)	1	50	15	50	20
TES26	*shop online (hrs per MONTH)	0	5	1	2	0
TES27	*use online banking (hrs per MONTH)	1	20	0	2	3
TES28	trust computers (yes/no)	1	1	0	1	1
TES29	experience with radio	2	1	1	4	4
TES30	experience with GPS	1	1	1	5	4
TES31	experience with topographical map	3	1	2	5	4
TES32	experience with military compass	2	4	2	5	4
TES33	experience with FBCB2 or BFT	0	0	0	4	0
TES34	experience with Tacticomp	0	0	0	0	0
TES35	experience with CDA or other RPDA	0	0	0	5	0
TES36	age	19	18	19	31	27
TES37	gender	M	M	M	M	M
TES38	pay grade	E2	E2	E3	O3	E6
TES39	branch of service	USMC	USMC	USMC	USA	USA
TES40	years enlisted service	1	1	1	0	9
TES41	years commissioned service	0	0	0	9	0
TES42	designator, MOS, or rating	2600	2600	2670	35D	98G
TES43	level of education (1-5)	2	2	3	4	3
TES44	current assignment	*	*	*	*	*
TES45a	special schools: Ranger	0	0	0	0	0
TES45b	special schools: Pathfinder	0	0	0	0	0
TES45c	special schools: EIB	0	0	0	0	0
TES45d	special schools: Air Assault	0	0	0	0	1
TES45e	special schools: NCO Course	0	0	0	0	1
TES45f	special schools: SNCO Course	0	0	0	0	0
TES45g	special schools: Computer Training	0	0	0	0	0
TES45h	special schools: HALO	0	0	0	0	0

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		RPDA-D				
		listed in order tested -->				
	Participant Number	0513	0514	0515	0528	0527
	Device used *this trial*	4	4	4	4	4
	Order	1	1	1	1	1
HDE1	location					
HDE2	date					
HDE3	description of scenario					
HDE4	description of features					
HDE5a	# text messages sent (attempted)	3	3	4	5	5
HDE5b	# text messages sent (successful)	3	3	3	5	5
HDE6	satisfaction with text messages sent	4	5	4	5	5
HDE7a	# text messages received (attempted)	3	3	3	3	3
HDE7b	# text messages received (successful)	3	3	3	3	3
HDE8	satisfaction with text messages received	5	5	5	5	5
HDE9	satisfaction with comm and network	4	5	4	5	4
HDE10	satisfaction with reliability of comm and network	5	5	4	5	5
HDE11	satisfaction with still images	3	3	4	4	5
HDE12a	# moving videos viewed (attempted)	6	6	0	0	0
HDE12b	# moving videos viewed (successful)	6	6	0	0	0
HDE13	satisfaction with quality of moving video	5	5	0	0	0
HDE14a	# audio files listened to (attempted)	6	6	0	0	0
HDE14b	# audio files listened to (successful)	6	6	0	0	0
HDE15	satisfaction with quality of audio files	5	5	0	0	0
HDE16a	# of uses of mapping functions (attempted)	5	5	3	3	3
HDE16b	# of uses of mapping functions (successful)	5	5	3	3	3
HDE17	satisfaction with mapping functions	4	4	4	4	5
HDE18	satisfaction with SA tools	3	3	0	4	0
HDE19a	# of uses of stylus (attempted)	10	10	7	10	20
HDE19b	# of uses of stylus (successful)	10	10	7	10	20
HDE20	satisfaction with stylus	3	4	4	4	5
HDE21a	# of uses of buttons (attempted)	0	0	0	0	0
HDE21b	# of uses of buttons (successful)	0	0	0	0	0
HDE22	satisfaction with buttons	0	0	0	0	0
HDE23	satisfaction with one handed operation	0	0	0	2	0
HDE24	satisfaction with removing device to use it	0	0	0	0	0
HDE25	satisfaction with stowing device	0	0	0	0	0
HDE26	ability to use personal weapon	2	0	2	0	0
HDE27	ability to read the screen	0	0	0	0	0
HDE28	overall satisfaction with reliability	4	4	5	0	4
HDE29	overall satisfaction with ruggedness	3	3	0	4	0
HDE30	overall satisfaction with system	4	4	4	4	5
HDE31	impression of ease of learning and use	3	4	4	5	5
HDE32	free comments					

	Participant Number	0502	0506	0501	0503	0505	0504
TES1	have cell phone (yes/no)	0	0	0	1	1	1
TES2	talk on phone (hours)	0	7	0	14	5	5
TES3	use text messaging (hours)	0	0	0	2	2	0
TES4	customize cell phone (hours)	0	0	0	1	1	1
TES5	play games on cell phone (hours)	0	1	0	0	1	0
TES6	phone numbers stored in cell phone (#)	0	40	0	70	30	20
TES7	PDA use	1	2	1	2	1	1
TES8	PDA stylus use	1	3	1	3	1	1
TES9	video game play (hours)	10	0	6	50	2	3
TES10	online video games (yes/no)	0	0	0	1	1	1
TES11	home computer video games (yes/no)	0	0	1	1	1	1
TES12	video game system video games (yes/no)	1	1	1	1	1	0
TES13	list favorite games	*	*	*	*	*	*
TES14	has work computer for own use (yes/no)	0	1	0	1	1	0
TES15	has shared work computer (yes/no)	0	0	1	1	1	0
TES16	almost never use computer at work (yes/no)	0	0		0	0	1
TES17	use computer in living quarters (yes/no)	1	0		0	0	1
TES18	use public computers (yes/no)	1	1		1	1	1
TES19	use several programs at same time (yes/no)	0	1		1	1	1
TES20.1	computer problem: a. stop	4	4	5		5	4
TES20.2	computer problem: b. read manual	5	5	4		3	5
TES20.3	computer problem: c. read help	3	2	1		2	3
TES20.4	computer problem: d. ask for help	2	3	3	2	4	1
TES20.5	computer problem: e. keep trying	1	1	2	1	1	2

	Participant Number	0502	0506	0501	0503	0505	0504
TES21	use a computer				4		
TES22	*use email (hrs per week)	1	10	2	140	20	20
TES23	*use email attachments (hrs per week)	0	1	0	50	10	5
TES24	*use online chat or IM (hrs per week)	0	0	0	7	15	5
TES25	*use internet to find information (hrs per week)	1	70	1	7	20	20
TES26	*shop online (hrs per MONTH)	0	4	3	4	3	0
TES27	*use online banking (hrs per MONTH)	0	2	0	2	5	10
TES28	trust computers (yes/no)	1	1	1	1	1	1
TES29	experience with radio	1	1	1	0	1	0
TES30	experience with GPS	0	0	1	0	1	0
TES31	experience with topographical map	3	1	2	3	2	1
TES32	experience with military compass	3	1	2	3	2	1
TES33	experience with FBCB2 or BFT	0	0	1	0	0	0
TES34	experience with Tacticomp	0	1	1	0	0	0
TES35	experience with CDA or other RPDA	0	0	1	0	0	0
TES36	age	24	36	20	18	19	21
TES37	gender	M	M	M	M	M	F
TES38	pay grade	E4	E4	E3	E2	E2	E3
TES39	branch of service	USA	USA	USA	USA	USA	USA
TES40	years enlisted service	1	1	1	1	1	1
TES41	years commissioned service	0	0	0	0	0	0
TES42	designator, MOS, or rating	98X	97E	98	98G	98X	98G
TES43	level of education (1-5)	4	4	3	2	3	3
TES44	current assignment	*			*	*	
TES45a	special schools: Ranger	0	0	0	0	0	0
TES45b	special schools: Pathfinder	0	0	0	0	0	0
TES45c	special schools: EIB	0	0	0	0	0	0
TES45d	special schools: Air Assault	0	0	0	0	0	0
TES45e	special schools: NCO Course	0	0	0	0	0	0
TES45f	special schools: SNCO Course	0	0	0	0	0	0
TES45g	special schools: Computer Training	0	0	0	0	0	0
TES45h	special schools: HALO	0	0	0	0	0	0

Takagi Thesis Raw Data

		RPDA-A					
	Participant Number	0502	0506	0501	0503	0505	0504
	Device used *this trial*	1	1	1	1	1	1
	Order	1	1	2	2	1	2
HDE1	location						
HDE2	date						
HDE3	description of scenario						
HDE4	description of features						
HDE5a	# text messages sent (attempted)	5	2	5		4	
HDE5b	# text messages sent (successful)	5	2	5		4	
HDE6	satisfaction with text messages sent	4	4	4		4	
HDE7a	# text messages received (attempted)	5	3	5		4	
HDE7b	# text messages received (successful)	5	3	5		4	
HDE8	satisfaction with text messages received	5	5	4		5	
HDE9	satisfaction with comm and network	4	4	4		4	
HDE10	satisfaction with reliability of comm and network	5	2	4		4	
HDE11	satisfaction with still images	4	4	1		3	
HDE12a	# moving videos viewed (attempted)	1	6	0		6	
HDE12b	# moving videos viewed (successful)	1	6	0		6	
HDE13	satisfaction with quality of moving video	5	5	0		5	
HDE14a	# audio files listened to (attempted)	1	7	0		6	
HDE14b	# audio files listened to (successful)	1	7	0		6	
HDE15	satisfaction with quality of audio files	5	5	0		5	
HDE16a	# of uses of mapping functions (attempted)	3	4	3		5	
HDE16b	# of uses of mapping functions (successful)	3	4	3		5	
HDE17	satisfaction with mapping functions	4	2	3		4	
HDE18	satisfaction with SA tools	0	3	4		5	
HDE19a	# of uses of stylus (attempted)	75	7	8		10	
HDE19b	# of uses of stylus (successful)	75	7	8		10	
HDE20	satisfaction with stylus	5	4	1		5	
HDE21a	# of uses of buttons (attempted)	0	0	0		1	
HDE21b	# of uses of buttons (successful)	0	0	0		1	
HDE22	satisfaction with buttons	0	0	0		3	
HDE23	satisfaction with one handed operation	2	3	1		5	
HDE24	satisfaction with removing device to use it	0	2	0		3	
HDE25	satisfaction with stowing device	0	0	3		3	
HDE26	ability to use personal weapon	1	2	1		2	
HDE27	ability to read the screen	5	0	0		4	
HDE28	overall satisfaction with reliability	5	5	2		5	
HDE29	overall satisfaction with ruggedness	5	0	0		5	
HDE30	overall satisfaction with system	5	4	2		5	
HDE31	impression of ease of learning and use	5	5	5		5	
HDE32	free comments	*	**	*		*	

		RPDA-B					
Participant Number		0502	0506	0501	0503	0505	0504
	Device used *this trial*	2	2	2	2	2	2
	Order	2	2	1	1	2	1
HDE1	location						
HDE2	date						
HDE3	description of scenario						
HDE4	description of features						
HDE5a	# text messages sent (attempted)	1		6		1	
HDE5b	# text messages sent (successful)	1		6		1	
HDE6	satisfaction with text messages sent	1		4		4	
HDE7a	# text messages received (attempted)	1		6		1	
HDE7b	# text messages received (successful)	1		6		1	
HDE8	satisfaction with text messages received	5		4		5	
HDE9	satisfaction with comm and network	2		4		4	
HDE10	satisfaction with reliability of comm and network	5		5		5	
HDE11	satisfaction with still images	3		2		4	
HDE12a	# moving videos viewed (attempted)	0		0		1	
HDE12b	# moving videos viewed (successful)	0		0		1	
HDE13	satisfaction with quality of moving video	0		0		4	
HDE14a	# audio files listened to (attempted)	0		0		1	
HDE14b	# audio files listened to (successful)	0		0		1	
HDE15	satisfaction with quality of audio files	0		0		4	
HDE16a	# of uses of mapping functions (attempted)	3		3		2	
HDE16b	# of uses of mapping functions (successful)	3		3		2	
HDE17	satisfaction with mapping functions	3		2		4	
HDE18	satisfaction with SA tools	0		3		5	
HDE19a	# of uses of stylus (attempted)	50		7		3	
HDE19b	# of uses of stylus (successful)	10		7		3	
HDE20	satisfaction with stylus	1		4		4	
HDE21a	# of uses of buttons (attempted)	0		0		0	
HDE21b	# of uses of buttons (successful)	0		0		0	
HDE22	satisfaction with buttons	0		0		0	
HDE23	satisfaction with one handed operation	0		1		3	
HDE24	satisfaction with removing device to use it	0		3		0	
HDE25	satisfaction with stowing device	0		3		0	
HDE26	ability to use personal weapon	0		1		3	
HDE27	ability to read the screen	0		5		4	
HDE28	overall satisfaction with reliability	1		4		5	
HDE29	overall satisfaction with ruggedness	0		0		5	
HDE30	overall satisfaction with system	1		4		5	
HDE31	impression of ease of learning and use	5		5		5	
HDE32	free comments	*		**		*	

		No Device		
	Participant Number	0507	0517	0518
TES1	have cell phone (yes/no)	0	1	1
TES2	talk on phone (hours)	0	6	5
TES3	use text messaging (hours)	0	1	0
TES4	customize cell phone (hours)	0	1	0
TES5	play games on cell phone (hours)	0	0	0
TES6	phone numbers stored in cell phone (#)	0	40	20
TES7	PDA use	2	1	1
TES8	PDA stylus use	4	1	1
TES9	video game play (hours)	5	8	3
TES10	online video games (yes/no)	1	0	0
TES11	home computer video games (yes/no)	1	0	0
TES12	video game system video games (yes/no)	0	1	1
TES13	list favorite games	*	*	*
TES14	has work computer for own use (yes/no)	0	0	1
TES15	has shared work computer (yes/no)	1	1	0
TES16	almost never use computer at work (yes/no)	1	1	0
TES17	use computer in living quarters (yes/no)	0	0	0
TES18	use public computers (yes/no)	1	1	0
TES19	use several programs at same time (yes/no)	1	1	1
TES20.1	computer problem: a. stop			5
TES20.2	computer problem: b. read manual			4
TES20.3	computer problem: c. read help			3
TES20.4	computer problem: d. ask for help			2
TES20.5	computer problem: e. keep trying	1	1	1

		No Device		
	Participant Number	0507	0517	0518
TES21	use a computer			
TES22	*use email (hrs per week)	35	4	100
TES23	*use email attachments (hrs per week)	5	2	20
TES24	*use online chat or IM (hrs per week)	0	1	0
TES25	*use internet to find information (hrs per week)	7	7	50
TES26	*shop online (hrs per MONTH)	0	4	2
TES27	*use online banking (hrs per MONTH)	2	2	0
TES28	trust computers (yes/no)	1	1	0
TES29	experience with radio	1	1	3
TES30	experience with GPS	0	1	4
TES31	experience with topographical map	2	2	5
TES32	experience with military compass	3	2	5
TES33	experience with FBCB2 or BFT	0	1	0
TES34	experience with Tacticomp	0	1	0
TES35	experience with CDA or other RPDA	0	1	0
TES36	age	18	22	35
TES37	gender	M	M	M
TES38	pay grade	E2	E4	E5
TES39	branch of service	USA	USMC	USA
TES40	years enlisted service	1	2	9
TES41	years commissioned service	0	0	0
TES42	designator, MOS, or rating	1ET	2600	11B2P
TES43	level of education (1-5)	2	3	2
TES44	current assignment	*	*	*
TES45a	special schools: Ranger	0	0	0
TES45b	special schools: Pathfinder	0	0	0
TES45c	special schools: EIB	0	0	0
TES45d	special schools: Air Assault	0	0	0
TES45e	special schools: NCO Course	0	0	1
TES45f	special schools: SNCO Course	0	0	0
TES45g	special schools: Computer Training	0	0	0
TES45h	special schools: HALO	0	0	0

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4. SURVEY DATA: AGGREGATE SUMMARY OF RESPONSES

Takagi Thesis Survey Aggregate Results

dark	= 80% or more		Overall							
light	= 50% to 80%		n/a							
			no	yes						
Eval		Category	0	1	2	3	4	5	Total
TES	1	have cell phone (yes/no)	36%	64%					14
TES	2	talk on phone (hours)	median=	5.00	mean=	4.69	sd=	4.09	14
TES	3	use text messaging (hours)	median=	-	mean=	0.77	sd=	0.93	14
TES	4	customize cell phone (hours)	median=	0.20	mean=	0.48	sd=	0.51	14
TES	5	play games on cell phone (hours)	median=	-	mean=	0.38	sd=	0.65	14
TES	6	phone numbers stored in cell phone (#)	median=	30.00	mean=	33.46	sd=	32.24	14
TES	7	PDA use		50%	50%				14
TES	8	PDA stylus use		50%		43%	7%		14
TES	9	video game play (hours)	median=	5.00	mean=	7.92	sd=	13.02	14
TES	10	online video games (yes/no)	57%	43%					14
TES	11	home computer video games (yes/no)	43%	57%					14
TES	12	video game system video games (yes/no)	29%	71%					14
TES	13	list favorite games							13
TES	14	has work computer for own use (yes/no)	57%	43%					14
TES	15	has shared work computer (yes/no)	50%	50%					14
TES	16	almost never use computer at work (yes/no)	69%	31%					13
TES	17	use computer in living quarters (yes/no)	46%	54%					13
TES	18	use public computers (yes/no)	31%	69%					13
TES	19	use several programs at same time (yes/no)	8%	92%					13
TES	20.1	computer problem: a. stop			9%		36%	55%	11
TES	20.2	computer problem: b. read manual				27%	27%	45%	11
TES	20.3	computer problem: c. read help		9%	45%	45%			11
TES	20.4	computer problem: d. ask for help		8%	33%	25%	33%		12
TES	20.5	computer problem: e. keep trying		86%	14%				14
	21	use a computer	median=	4.00	mean=	4.00	sd=	#DIV/0!	1
TES	22	use email (hrs per week)	median=	20.00	mean=	58.23	sd=	75.33	14
TES	23	use email attachments (hrs per week)	median=	5.00	mean=	18.92	sd=	30.15	14
TES	24	use online chat or IM (hrs per week)	median=	-	mean=	79.15	sd=	276.71	14
TES	25	use internet to find information (hrs per week)	median=	15.00	mean=	23.00	sd=	23.63	14
TES	26	shop online (hrs per MONTH)	median=	2.00	mean=	2.15	sd=	1.82	14
TES	27	use online banking (hrs per MONTH)	median=	2.00	mean=	3.54	sd=	5.65	14
TES	28	trust computers w/ personal info (yes/no)	14%	86%					14
TES	29	experience with radio	14%	57%	7%	7%	14%		14
TES	30	experience with GPS	36%	43%			14%	7%	14
TES	31	experience with topographical map		21%	36%	21%	7%	14%	14
TES	32	experience with military compass		14%	36%	21%	14%	14%	14
TES	33	experience with FBCB2 or BFT	79%	14%			7%		14
TES	34	experience with Tacticomp	79%	21%					14
TES	35	experience with CDA or other RPDA	79%	14%				7%	14

Takagi Thesis Survey Aggregate Results

| | | dark = 80% or more | | | | | | |
| | | light = 50% to 80% | | | | | | |

Eval		Category	Overall n/a no 0	yes 1	2	3	4	5	Total
TES	36	age	median=	20.00	mean=	23.08	sd=	6.55	14
TES	37	gender							14
TES	38	pay grade							14
TES	39	branch of service							14
TES	40	years enlisted service	median=	1.00	mean=	1.62	sd=	2.26	14
TES	41	years commissioned servcie	median=	-	mean=	0.75	sd=	2.60	14
TES	42	designator, MOS, or rating							14
TES	43	level of education (1-5)			36%	43%	21%		14
TES	44	current assignment							11
TES	45a	special schools: Ranger	100%						14
TES	45b	special schools: Pathfinder	100%						14
TES	45c	special schools: EIB	100%						14
TES	45d	special schools: Air Assault	93%	7%					14
TES	45e	special schools: NCO Course	86%	14%					14
TES	45f	special schools: SNCO Course	100%						14
TES	45g	special schools: Computer Training	100%						14
TES	45h	special schools: HALO	100%						14

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			Overall n/a no	yes						
dark = 80% or more										
light = 50% to 80%										
Eval		Category	0	1	2	3	4	5	Total	
		Device used this trial		35%	35%		29%		17	
		Device used *previously*							17	
HDE	1	location							0	
HDE	2	date							0	
HDE	3	description of scenario							0	
HDE	4	description of features							0	
HDE	5a	# text messages sent (attempted)	median=	4.00	mean=	3.67	sd=	1.67	12	
HDE	5b	# text messages sent (successful)	median=	3.50	mean=	3.58	sd=	1.68	12	
HDE	6	satisfaction with text messages sent		8%			67%	25%	12	
HDE	7a	# text messages received (attempted)	median=	3.00	mean=	3.33	sd=	1.50	12	
HDE	7b	# text messages received (successful)	median=	3.00	mean=	3.33	sd=	1.50	12	
HDE	8	satisfaction with text messages received					17%	83%	12	
HDE	9	satisfaction with comm and network			8%		75%	17%	12	
HDE	10	satisfaction with reliability of comm and network			8%		25%	67%	12	
HDE	11	satisfaction with still images		8%	8%	33%	42%	8%	12	
HDE	12a	# moving videos viewed (attempted)	median=	0.50	mean=	2.17	sd=	2.86	12	
HDE	12b	# moving videos viewed (successful)	median=	0.50	mean=	2.17	sd=	2.86	12	
HDE	13	satisfaction with quality of moving video	50%				8%	42%	12	
HDE	14a	# audio files listened to (attempted)	median=	0.50	mean=	2.25	sd=	2.99	12	
HDE	14b	# audio files listened to (successful)	median=	0.50	mean=	2.25	sd=	2.99	12	
HDE	15	satisfaction with quality of audio files	50%				8%	42%	12	
HDE	16a	# of uses of mapping functions (attempted)	median=	3.00	mean=	3.50	sd=	1.00	12	
HDE	16b	# of uses of mapping functions (successful)	median=	3.00	mean=	3.50	sd=	1.00	12	
HDE	17	satisfaction with mapping functions			17%	17%	58%	8%	12	
HDE	18	satisfaction with SA tools	33%			33%	17%	17%	12	
HDE	19a	# of uses of stylus (attempted)	median=	10.00	mean=	18.08	sd=	21.79	12	
HDE	19b	# of uses of stylus (successful)	median=	10.00	mean=	14.75	sd=	19.39	12	
HDE	20	satisfaction with stylus		17%		8%	50%	25%	12	
HDE	21a	# of uses of buttons (attempted)	median=	-	mean=	0.08	sd=	0.29	12	
HDE	21b	# of uses of buttons (successful)	median=	-	mean=	0.08	sd=	0.29	12	
HDE	22	satisfaction with buttons	92%			8%			12	
HDE	23	satisfaction with one handed operation	42%	17%	17%	17%		8%	12	
HDE	24	satisfaction with removing device to use it	75%		8%	17%			12	
HDE	25	satisfaction with stowing device	75%			25%			12	
HDE	26	ability to use personal weapon	33%	25%	33%	8%			12	
HDE	27	ability to read the screen	67%				17%	17%	12	
HDE	28	overall satisfaction with reliability	8%	8%	8%		33%	42%	12	
HDE	29	overall satisfaction with ruggedness	50%			17%	8%	25%	12	
HDE	30	overall satisfaction with system		8%	8%		50%	33%	12	
HDE	31	impression of ease of learning and use				8%	17%	75%	12	
HDE	32	free comments							7	

			n/a no	yes					
dark = 80% or more			**RPDA-D**						
light = 50% to 80%									
Eval		Category	0	1	2	3	4	5	Total
TES	1	have cell phone (yes/no)	40%	60%					5
TES	2	talk on phone (hours)	median=	5.00	mean=	4.75	sd=	3.69	5
TES	3	use text messaging (hours)	median=	1.50	mean=	1.25	sd=	0.96	5
TES	4	customize cell phone (hours)	median=	0.60	mean=	0.55	sd=	0.53	5
TES	5	play games on cell phone (hours)	median=	0.50	mean=	0.75	sd=	0.96	5
TES	6	phone numbers stored in cell phone (#)	median=	57.50	mean=	53.75	sd=	43.47	5
TES	7	PDA use	20%	80%					5
TES	8	PDA stylus use	20%			80%			5
TES	9	video game play (hours)	median=	4.50	mean=	4.00	sd=	3.56	5
TES	10	online video games (yes/no)	60%	40%					5
TES	11	home computer video games (yes/no)	40%	60%					5
TES	12	video game system video games (yes/no)	40%	60%					5
TES	13	list favorite games							4
TES	14	has work computer for own use (yes/no)	60%	40%					5
TES	15	has shared work computer (yes/no)	60%	40%					5
TES	16	almost never use computer at work (yes/no)	80%	20%					5
TES	17	use computer in living quarters (yes/no)		100%					5
TES	18	use public computers (yes/no)	60%	40%					5
TES	19	use several programs at same time (yes/no)		100%					5
TES	20.1	computer problem: a. stop			20%		20%	60%	5
TES	20.2	computer problem: b. read manual				40%	20%	40%	5
TES	20.3	computer problem: c. read help			60%	40%			5
TES	20.4	computer problem: d. ask for help			20%	20%	60%		5
TES	20.5	computer problem: e. keep trying		100%					5
	21	use a computer	median=	#NUM!	mean=	#DIV/0!	sd=	#DIV/0!	0
TES	22	use email (hrs per week)	median=	110.00	mean=	106.25	sd=	108.43	5
TES	23	use email attachments (hrs per week)	median=	26.00	mean=	38.25	sd=	47.09	5
TES	24	use online chat or IM (hrs per week)	median=	0.50	mean=	250.25	sd=	499.83	5
TES	25	use internet to find information (hrs per week)	median=	32.50	mean=	29.00	sd=	24.91	5
TES	26	shop online (hrs per MONTH)	median=	1.50	mean=	2.00	sd=	2.16	5
TES	27	use online banking (hrs per MONTH)	median=	1.50	mean=	5.75	sd=	9.54	5
TES	28	trust computers w/ personal info (yes/no)	20%	80%					5
TES	29	experience with radio		40%	20%		40%		5
TES	30	experience with GPS		60%			20%	20%	5
TES	31	experience with topographical map		20%	20%	20%	20%	20%	5
TES	32	experience with military compass			40%		40%	20%	5
TES	33	experience with FBCB2 or BFT	80%				20%		5
TES	34	experience with Tacticomp	100%						5
TES	35	experience with CDA or other RPDA	80%					20%	5

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Takagi Thesis Survey Aggregate Results

			dark = 80% or more	light = 50% to 80%

RPDA-D

Eval		Category	n/a no 0	yes 1	2	3	4	5	Total
TES	36	age	median=	19.00	mean=	21.75	sd=	6.18	5
TES	37	gender							5
TES	38	pay grade							5
TES	39	branch of service							5
TES	40	years enlisted service	median=	1.00	mean=	0.75	sd=	0.50	5
TES	41	years commissioned servcie	median=	-	mean=	2.25	sd=	4.50	5
TES	42	designator, MOS, or rating							5
TES	43	level of education (1-5)			40%	40%	20%		5
TES	44	current assignment							5
TES	45a	special schools: Ranger	100%						5
TES	45b	special schools: Pathfinder	100%						5
TES	45c	special schools: EIB	100%						5
TES	45d	special schools: Air Assault	80%	20%					5
TES	45e	special schools: NCO Course	80%	20%					5
TES	45f	special schools: SNCO Course	100%						5
TES	45g	special schools: Computer Training	100%						5
TES	45h	special schools: HALO	100%						5

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Takagi Thesis Survey Aggregate Results

dark	= 80% or more
light	= 50% to 80%

RPDA-D

Eval		Category	n/a no 0	yes 1	2	3	4	5	Total
		Device used this trial							5
		Device used *previously*							5
HDE	1	location							0
HDE	2	date							0
HDE	3	description of scenario							0
HDE	4	description of features							0
HDE	5a	# text messages sent (attempted)	median=	4.00	mean=	4.00	sd=	1.00	5
HDE	5b	# text messages sent (successful)	median=	3.00	mean=	3.80	sd=	1.10	5
HDE	6	satisfaction with text messages sent					40%	60%	5
HDE	7a	# text messages received (attempted)	median=	3.00	mean=	3.00	sd=	-	5
HDE	7b	# text messages received (successful)	median=	3.00	mean=	3.00	sd=	-	5
HDE	8	satisfaction with text messages received						100%	5
HDE	9	satisfaction with comm and network					60%	40%	5
HDE	10	satisfaction with reliability of comm and network					20%	80%	5
HDE	11	satisfaction with still images				40%	40%	20%	5
HDE	12a	# moving videos viewed (attempted)	median=	-	mean=	2.40	sd=	3.29	5
HDE	12b	# moving videos viewed (successful)	median=	-	mean=	2.40	sd=	3.29	5
HDE	13	satisfaction with quality of moving video	60%					40%	5
HDE	14a	# audio files listened to (attempted)	median=	-	mean=	2.40	sd=	3.29	5
HDE	14b	# audio files listened to (successful)	median=	-	mean=	2.40	sd=	3.29	5
HDE	15	satisfaction with quality of audio files	60%					40%	5
HDE	16a	# of uses of mapping functions (attempted)	median=	3.00	mean=	3.80	sd=	1.10	5
HDE	16b	# of uses of mapping functions (successful)	median=	3.00	mean=	3.80	sd=	1.10	5
HDE	17	satisfaction with mapping functions					80%	20%	5
HDE	18	satisfaction with SA tools	40%			40%	20%		5
HDE	19a	# of uses of stylus (attempted)	median=	10.00	mean=	11.40	sd=	4.98	5
HDE	19b	# of uses of stylus (successful)	median=	10.00	mean=	11.40	sd=	4.98	5
HDE	20	satisfaction with stylus				20%	60%	20%	5
HDE	21a	# of uses of buttons (attempted)	median=	-	mean=	-	sd=	-	5
HDE	21b	# of uses of buttons (successful)	median=	-	mean=	-	sd=	-	5
HDE	22	satisfaction with buttons	100%						5
HDE	23	satisfaction with one handed operation	80%		20%				5
HDE	24	satisfaction with removing device to use it	100%						5
HDE	25	satisfaction with stowing device	100%						5
HDE	26	ability to use personal weapon	60%		40%				5
HDE	27	ability to read the screen	100%						5
HDE	28	overall satisfaction with reliability	20%				60%	20%	5
HDE	29	overall satisfaction with ruggedness	40%			40%	20%		5
HDE	30	overall satisfaction with system					80%	20%	5
HDE	31	impression of ease of learning and use				20%	40%	40%	5
HDE	32	free comments							0

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Takagi Thesis Survey Aggregate Results

dark	= 80% or more
light	= 50% to 80%

RPDA-A

Eval		Category	n/a no 0	yes 1	2	3	4	5	Total
TES	1	have cell phone (yes/no)	33%	67%					6
TES	2	talk on phone (hours)	median=	5.00	mean=	5.17	sd=	5.19	6
TES	3	use text messaging (hours)	median=	-	mean=	0.67	sd=	1.03	6
TES	4	customize cell phone (hours)	median=	0.50	mean=	0.50	sd=	0.55	6
TES	5	play games on cell phone (hours)	median=	-	mean=	0.33	sd=	0.52	6
TES	6	phone numbers stored in cell phone (#)	median=	25.00	mean=	26.67	sd=	26.58	6
TES	7	PDA use		67%	33%				6
TES	8	PDA stylus use		67%		33%			6
TES	9	video game play (hours)	median=	4.50	mean=	11.83	sd=	19.02	6
TES	10	online video games (yes/no)	50%	50%					6
TES	11	home computer video games (yes/no)	33%	67%					6
TES	12	video game system video games (yes/no)	17%	83%					6
TES	13	list favorite games	median=	#NUM!	mean=	#DIV/0!	sd=	#DIV/0!	6
TES	14	has work computer for own use (yes/no)	50%	50%					6
TES	15	has shared work computer (yes/no)	50%	50%					6
TES	16	almost never use computer at work (yes/no)	80%	20%					5
TES	17	use computer in living quarters (yes/no)	60%	40%					5
TES	18	use public computers (yes/no)		100%					5
TES	19	use several programs at same time (yes/no)	20%	80%					5
TES	20.1	computer problem: a. stop					60%	40%	5
TES	20.2	computer problem: b. read manual				20%	20%	60%	5
TES	20.3	computer problem: c. read help		20%	40%	40%			5
TES	20.4	computer problem: d. ask for help		17%	33%	33%	17%		6
TES	20.5	computer problem: e. keep trying		67%	33%				6
	21	use a computer	median=	4.00	mean=	4.00	sd=	#DIV/0!	1
TES	22	use email (hrs per week)	median=	15.00	mean=	32.17	sd=	53.47	6
TES	23	use email attachments (hrs per week)	median=	3.00	mean=	11.00	sd=	19.49	6
TES	24	use online chat or IM (hrs per week)	median=	2.50	mean=	4.50	sd=	5.96	6
TES	25	use internet to find information (hrs per week)	median=	13.50	mean=	19.83	sd=	26.04	6
TES	26	shop online (hrs per MONTH)	median=	3.00	mean=	2.33	sd=	1.86	6
TES	27	use online banking (hrs per MONTH)	median=	2.00	mean=	3.17	sd=	3.82	6
TES	28	trust computers w/ personal info (yes/no)		100%					6
TES	29	experience with radio	33%	67%					6
TES	30	experience with GPS	67%	33%					6
TES	31	experience with topographical map		33%	33%	33%			6
TES	32	experience with military compass		33%	33%	33%			6
TES	33	experience with FBCB2 or BFT	83%	17%					6
TES	34	experience with Tacticomp	67%	33%					6
TES	35	experience with CDA or other RPDA	83%	17%					6

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Takagi Thesis Survey Aggregate Results

dark	= 80% or more
light	= 50% to 80%

RPDA-A

Eval		Category	n/a no 0	yes 1	2	3	4	5	Total
TES	36	age	median=	20.50	mean=	23.00	sd=	6.69	6
TES	37	gender							6
TES	38	pay grade	median=	#NUM!	mean=	#DIV/0!	sd=	#DIV/0!	6
TES	39	branch of service	median=	#NUM!	mean=	#DIV/0!	sd=	#DIV/0!	6
TES	40	years enlisted service	median=	1.00	mean=	1.00	sd=	-	6
TES	41	years commissioned servcie	median=	-	mean=	-	sd=	-	6
TES	42	designator, MOS, or rating	median=	98.00	mean=	98.00	sd=	#DIV/0!	6
TES	43	level of education (1-5)			17%	50%	33%		6
TES	44	current assignment							3
TES	45a	special schools: Ranger	100%						6
TES	45b	special schools: Pathfinder	100%						6
TES	45c	special schools: EIB	100%						6
TES	45d	special schools: Air Assault	100%						6
TES	45e	special schools: NCO Course	100%						6
TES	45f	special schools: SNCO Course	100%						6
TES	45g	special schools: Computer Training	100%						6
TES	45h	special schools: HALO	100%						6
									0
									0
									0

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Takagi Thesis Survey Aggregate Results

			dark = 80% or more						
			light = 50% to 80%						

RPDA-A

Eval		Category	n/a no 0	yes 1	2	3	4	5	Total
		Device used this trial							6
		Device used *previously*							6
HDE	1	location							0
HDE	2	date							0
HDE	3	description of scenario							0
HDE	4	description of features							0
HDE	5a	# text messages sent (attempted)	median=	4.50	mean=	4.00	sd=	1.41	4
HDE	5b	# text messages sent (successful)	median=	4.50	mean=	4.00	sd=	1.41	4
HDE	6	satisfaction with text messages sent					100%		4
HDE	7a	# text messages received (attempted)	median=	4.50	mean=	4.25	sd=	0.96	4
HDE	7b	# text messages received (successful)	median=	4.50	mean=	4.25	sd=	0.96	4
HDE	8	satisfaction with text messages received					25%	75%	4
HDE	9	satisfaction with comm and network					100%		4
HDE	10	satisfaction with reliability of comm and network			25%		50%	25%	4
HDE	11	satisfaction with still images		25%		25%	50%		4
HDE	12a	# moving videos viewed (attempted)	median=	3.50	mean=	3.25	sd=	3.20	4
HDE	12b	# moving videos viewed (successful)	median=	3.50	mean=	3.25	sd=	3.20	4
HDE	13	satisfaction with quality of moving video	25%					75%	4
HDE	14a	# audio files listened to (attempted)	median=	3.50	mean=	3.50	sd=	3.51	4
HDE	14b	# audio files listened to (successful)	median=	3.50	mean=	3.50	sd=	3.51	4
HDE	15	satisfaction with quality of audio files	25%					75%	4
HDE	16a	# of uses of mapping functions (attempted)	median=	3.50	mean=	3.75	sd=	0.96	4
HDE	16b	# of uses of mapping functions (successful)	median=	3.50	mean=	3.75	sd=	0.96	4
HDE	17	satisfaction with mapping functions			25%	25%	50%		4
HDE	18	satisfaction with SA tools	25%			25%	25%	25%	4
HDE	19a	# of uses of stylus (attempted)	median=	9.00	mean=	25.00	sd=	33.36	4
HDE	19b	# of uses of stylus (successful)	median=	9.00	mean=	25.00	sd=	33.36	4
HDE	20	satisfaction with stylus		25%			25%	50%	4
HDE	21a	# of uses of buttons (attempted)	median=	-	mean=	0.25	sd=	0.50	4
HDE	21b	# of uses of buttons (successful)	median=	-	mean=	0.25	sd=	0.50	4
HDE	22	satisfaction with buttons	75%			25%			4
HDE	23	satisfaction with one handed operation		25%	25%	25%		25%	4
HDE	24	satisfaction with removing device to use it	50%		25%	25%			4
HDE	25	satisfaction with stowing device	50%			50%			4
HDE	26	ability to use personal weapon		50%	50%				4
HDE	27	ability to read the screen	50%				25%	25%	4
HDE	28	overall satisfaction with reliability			25%			75%	4
HDE	29	overall satisfaction with ruggedness	50%					50%	4
HDE	30	overall satisfaction with system			25%		25%	50%	4
HDE	31	impression of ease of learning and use						100%	4
HDE	32	free comments							4

Takagi Thesis Survey Aggregate Results

RPDA-B

Eval		Category	n/a no 0	yes 1	2	3	4	5	Total
		Device used this trial							6
		Device used *previously*							6
HDE	1	location							0
HDE	2	date							0
HDE	3	description of scenario							0
HDE	4	description of features							0
HDE	5a	# text messages sent (attempted)	median=	1.00	mean=	2.67	sd=	2.89	3
HDE	5b	# text messages sent (successful)	median=	1.00	mean=	2.67	sd=	2.89	3
HDE	6	satisfaction with text messages sent		33%			67%		3
HDE	7a	# text messages received (attempted)	median=	1.00	mean=	2.67	sd=	2.89	3
HDE	7b	# text messages received (successful)	median=	1.00	mean=	2.67	sd=	2.89	3
HDE	8	satisfaction with text messages received					33%	67%	3
HDE	9	satisfaction with comm and network			33%		67%		3
HDE	10	satisfaction with reliability of comm and network						100%	3
HDE	11	satisfaction with still images			33%	33%	33%		3
HDE	12a	# moving videos viewed (attempted)	median=	-	mean=	0.33	sd=	0.58	3
HDE	12b	# moving videos viewed (successful)	median=	-	mean=	0.33	sd=	0.58	3
HDE	13	satisfaction with quality of moving video	67%				33%		3
HDE	14a	# audio files listened to (attempted)	median=	-	mean=	0.33	sd=	0.58	3
HDE	14b	# audio files listened to (successful)	median=	-	mean=	0.33	sd=	0.58	3
HDE	15	satisfaction with quality of audio files	67%				33%		3
HDE	16a	# of uses of mapping functions (attempted)	median=	3.00	mean=	2.67	sd=	0.58	3
HDE	16b	# of uses of mapping functions (successful)	median=	3.00	mean=	2.67	sd=	0.58	3
HDE	17	satisfaction with mapping functions			33%	33%	33%		3
HDE	18	satisfaction with SA tools	33%			33%		33%	3
HDE	19a	# of uses of stylus (attempted)	median=	7.00	mean=	20.00	sd=	26.06	3
HDE	19b	# of uses of stylus (successful)	median=	7.00	mean=	6.67	sd=	3.51	3
HDE	20	satisfaction with stylus		33%			67%		3
HDE	21a	# of uses of buttons (attempted)	median=	-	mean=	-	sd=	-	3
HDE	21b	# of uses of buttons (successful)	median=	-	mean=	-	sd=	-	3
HDE	22	satisfaction with buttons	100%						3
HDE	23	satisfaction with one handed operation	33%	33%		33%			3
HDE	24	satisfaction with removing device to use it	67%			33%			3
HDE	25	satisfaction with stowing device	67%			33%			3
HDE	26	ability to use personal weapon	33%	33%		33%			3
HDE	27	ability to read the screen	33%				33%	33%	3
HDE	28	overall satisfaction with reliability		33%			33%	33%	3
HDE	29	overall satisfaction with ruggedness	67%					33%	3
HDE	30	overall satisfaction with system		33%			33%	33%	3
HDE	31	impression of ease of learning and use						100%	3
HDE	32	free comments	median=	#NUM!	mean=	#DIV/0!	sd=	#DIV/0!	3

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5. USABILITY TEST DATA

The observations recorded using Noldus Observer were summarized using Elementary Statistics, Total Durations, and then exported to Microsoft Excel. The tables below show the data in Excel, formatted for clarity. The Scored By column indicates the coder who scored that video. When both coders scored the same file, the REV (reviewed) column was created by averaging the two observations. If the two observations were off by more than ten seconds, the original video was reviewed to see if one coder had made an error or misinterpreted the scoring criteria. In that case, the REV column contains the more accurate score based on the later review.

Participant ID	501	502	503	503	503	504	504	504	505	505	505	506	501	502
Scored By	KB	KT	KB	KT	REV	KB	KT	REV	KB	KT	REV	KT	KB	KB
Device Tested	A	A	A	A	A	A	A	A	A	A	A	A	B	B
Time in Service	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pay Grade	E3	E4	E2	E2	E2	E3	E3	E3	E2	E2	E2	E4	E3	E4
Easy to Learn	5	5	0	0	0	0	5	5	5	5	5	5	5	1
Overall Satisfaction	2	5	0	0	0	0	5	5	5	5	5	4	4	5
on 1c comm chk	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 2c plot rte	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 3c read grid	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 4c brg rng	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 5c send msg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 6c rcv msg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 7c read back	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 1a comm chk	38	74	36	43	36	0	0	0	35	45	40	26	0	0
on 2a plot rte	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 3a read grid	130	289	104	221	104	39	42	40.5	12	44	12	82	162	79
on 4a brg rng	18	79	29	38	38	0	0	0	43	116	43	111	0	0
on 5a send msg	154	247	194	197	196	64	72	68	131	85	131	121	79	60
on 6a rcv msg	117	15	26	28	27	0	0	0	16	18	17	13	0	0
on 7a read back	8	9	9	9	9	4	8	6	7	6	6.5	25	0	0

	502	502	503	503	503	504	504	504	505	505	505	506	513	513
Participant ID	502	502	503	503	503	504	504	504	505	505	505	506	513	513
Scored By	KT	REV	KB	KT	REV	KB	KT	REV	KB	KT	REV	KT	KB	KT
Device Tested	B	B	B	B	B	B	B	B	B	B	B	B	D	D
Time in Service	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pay Grade	E4	E4	E2	E2	E2	E3	E3	E3	E2	E2	E2	E4	E2	E2
Easy to Learn	1	1	0	0	0	0	5	5	5	5	5	0	3	3
Overall Satisfaction	5	5	0	0	0	0	5	5	5	5	5	0	4	4
on 1c comm chk	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 2c plot rte	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 3c read grid	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 4c brg rng	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 5c send msg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 6c rcv msg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 7c read back	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 1a comm chk	0	0	0	0	0	0	0	0	0	0	0	0	22	22
on 2a plot rte	0	0	0	0	0	0	0	0	0	0	0	0	56	54
on 3a read grid	106	79	52	133	52	108	131	108	60	78	78	45	11	9
on 4a brg rng	0	0	0	0	0	0	0	0	0	0	0	0	25	25
on 5a send msg	65	62.5	57	56	56.5	88	84	86	110	111	111	57	92	92
on 6a rcv msg	0	0	0	0	0	0	7	0	0	0	0	0	19	25
on 7a read back	0	0	0	0	0	0	0	0	0	0	0	0	5	6

Participant ID	513	514	514	514	515	527	528	501	502	503	503	503	504	505
Scored By	REV	KB	KT	REV	KB	KB	KB	KB	KT	KB	KT	REV	KT	KB
Device Tested	D	D	D	D	D	D	D	Z	Z	Z	Z	Z	Z	Z
Time in Service	1	1	1	1	1	9	9	1	1	1	1	1	1	1
Pay Grade	E2	E2	E2	E2	E3	E6	O3	E3	E4	E2	E2	E2	E3	E2
Easy to Learn	3	4	4	4	4	5	5	5	0	0	0	0	5	0
Overall Satisfaction	4	4	4	4	4	5	4	4	0	0	0	0	5	0
on 1c comm chk	0	0	0	0	0	0	0	5	0	13	19	16	0	13
on 2c plot rte	0	0	0	0	0	0	0	502	264	314	322	318	197	290
on 3c read grid	0	0	0	0	0	0	0	100	40	27	19	23	97	31
on 4c brg rng	0	0	0	0	0	0	0	89	78	45	53	49	0	106
on 5c send msg	0	0	0	0	0	0	0	5	15	23	28	25.5	0	15
on 6c rcv msg	0	0	0	0	0	0	0	52	30	32	22	32	0	44
on 7c read back	0	0	0	0	0	0	0	3	14	33	32	32.5	0	7
on 1a comm chk	22	19	25	22	2	1	1	0	0	0	0	0	0	0
on 2a plot rte	55	118	46	46	92	46	42	0	0	0	0	0	0	0
on 3a read grid	10	17	14	15.5	12	12	13	0	0	0	0	0	0	0
on 4a brg rng	25	27	38	32.5	8	12	18	0	0	0	0	0	0	0
on 5a send msg	92	63	62	62.5	78	93	78	0	0	0	0	0	0	0
on 6a rcv msg	22	8	3	5.5	12	16	4	0	0	0	0	0	0	0
on 7a read back	5.5	54	55	54.5	3	20	5	0	0	0	0	0	0	0

Participant ID	505	505	506	513	513	513	514	514	514	515	527	527	527	528
Scored By	KT	REV	KT	KB	KT	REV	KB	KT	REV	KB	KB	KT	REV	KB
Device Tested	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
Time in Service	1	1	1	1	1	1	1	1	1	1	9	9	9	9
Pay Grade	E2	E2	E4	E2	E2	E2	E2	E2	E2	E3	E6	E6	E6	O3
Easy to Learn	0	0	0	3	0	0	4	0	0	0	0	5	5	5
Overall Satisfaction	0	0	0	4	0	0	4	0	0	0	0	5	5	4
on 1c comm chk	16	14.5	14	29	32	30.5	9	14	11.5	15	29	10	10	7
on 2c plot rte	309	290	321	305	309	307	278	258	258	286	211	189	189	231
on 3c read grid	56	31	29	30	34	32	12	12	12	31	1	4	2.5	5
on 4c brg rng	119	113	111	80	80	80	88	83	85.5	84	38	37	37.5	38
on 5c send msg	29	15	23	15	16	15.5	36	37	36.5	15	61	66	63.5	18
on 6c rcv msg	79	44	51	16	26	21	30	43	43	18	8	29	29	27
on 7c read back	5	6	18	12	12	12	12	10	11	5	1	5	3	0
on 1a comm chk	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 2a plot rte	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 3a read grid	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 4a brg rng	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 5a send msg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 6a rcv msg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
on 7a read back	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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APPENDIX L.   MORS-TISDALE PRESENTATION

This thesis was the winning entry in the Military Operations Research Society's (MORS) – Tisdale Graduate Research Award competition. The following presentation was presented to the faculty of the NPS Operations Research Department for the competition on September 6, 2005.

Slide # 1

Put this slide up immediately and leave up for introduction. Go to next slide automatically when speaker gets to that point.

"Good afternoon, I am Captain Koichi Takagi and I am honored to be here in front of you. "

[NEXT SLIDE]

technical note:
AWE Blue: Red 0, Green 114, Blue 188
Presentation font: TW Cen MT Condensed

Background
Applied Warfighter Ergonomics Center
Approach
Case Study
Conclusions
Question and Answer period

Slide # 2

"I will present an overview of my thesis, and briefly demonstrate some of the capabilities of our laboratory. I have a lot of backup material on hand, so at the end, we can go into more detail about any of the topics."

[PAUSE - NEXT SLIDE]

Acknowledgements

thesis advisor	Nita Lewis Miller, PhD
second reader	Nick Dew, PhD (GSBPP)
HSI research assistant	Melissa Smith Takagi, MLS
expert advice	Robert Koyak, PhD
	Lyn Whitaker, PhD
technical assistance	Derek Read, 1stLt USAF
	Matt Simpson, 1stLt USAF
	Francisco Caceres, Capt USMC
GSOIS student intern	Katie Buettner, UCSD

Slide # 3

"None of this would have been possible without the support of our research sponsors and the patience of my dear family and friends. "

[NEXT SLIDE]

Acknowledgements

TNT project director	Dave Netzer, PhD
sponsors	US Army SOC
	SOCOM
	Rapid Equipping Force
	TRAC Monterey
research participants	229 MI Bn, DLI
	Marine Detachment, DLI
inspiration	OR faculty and students

Slide # 4

"I also gratefully acknowledge the many students and faculty that have made this last seven-hundred and ninety-one days, seven hours, and __ minutes bearable, enriching, and meaningful. "

[NEXT SLIDE]

[0:35]

[from start of refresher qtr, 8 July 2003, to 1500 on Sep 6 ;-)]*

Background

Slide # 5

[CLICK VIDEO TO PLAY, AND THEN CLOSE WINDOWS MEDIA PLAYER COMPLETELY]

"End users bear the burden of poor design. Usability testing must involve representative participants under realistic conditions... There is a human factors gap in the T&E process. This video shows British Royal Marines landing in Basra using equipment that may not have been tested by the right people under the right conditions."

Various military agencies are currently fielding a number of devices known collectively as Ruggedized Personal Digital Assistants, or RPDAs, "

[NEXT SLIDE]

Ruggedized Personal Digital Assistants (RPDAs)

Slide # 6

"... including these, which we have been testing within the Tactical Network Topology project. RPDAs have unique human factors considerations.

Civilian PDAs are not designed to be used while the operator..."

[NEXT SLIDE]

Military RPDA human factors considerations

1. Simultaneous demands on attention
2. Other individual equipment and weapons
3. Environmental extremes

Slide # 7

"... simultaneously attends to mental and physical stimuli,"

[NEXT SLIDE]

Military RPDA human factors considerations

1. Simultaneous demands on attention
2. **Other individual equipment and weapons**
3. Environmental extremes

Slide # 8

"...wears or employs other equipment and weapons, or ..."

[NEXT SLIDE]

Military RPDA human factors considerations

1. Simultaneous demands on attention
2. Other individual equipment and weapons
3. Environmental extremes

Slide # 9

"... operates under environmental extremes.

The Special Operations Command desired a human factors evaluation of the RPDAs they have fielded in Iraq and Afghanistan. "

[NEXT SLIDE]

Mission Statement

To design and establish a laboratory
and a methodology
for scientifically evaluating
the human factors considerations
of combat equipment used by military personnel
under both controlled laboratory
and realistic field conditions.

Slide # 10

"At the time, no DoD facility existed that was equipped to specifically test military individual equipment in the manner of software usability testing.

My research interest was to perform scientifically rigorous human factors evaluations that went beyond subjective observations and survey data. There was a need within the DoD for a laboratory and a reliable research methodology to do just that."

[NEXT SLIDE]

Interested Partners

Marine Corps Warfighting Lab
SOCOM (various components)
US Army Special Operations Command
US Army Rapid Equipping Force
US Army PEO Soldier
US Navy Human Performance Center
US Forest Service
NPS MOVES Institute
NPS Computer Science and ITM departments
Noldus Information Technology

Slide # 11

"We developed a state-of-the-art behavioral observation laboratory that has generated serious interest from a number of different agencies and is the basis for much future research at NPS. The developer of the software is using our lab as a model on their website."

[NEXT SLIDE]

Observing a user navigating
the NPS Python web page
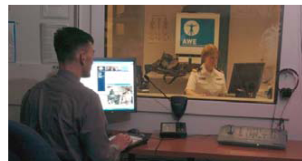
Slide # 12

Here in the lab, an observer watches the participant's computer screen broadcast to his own, while watching through a one-way mirror and recording everything to DVD files for later analysis."

[NEXT SLIDE]

52" stereo plasma display

Slide # 13

"Your handouts give more detail about the lab equipment.

Aside from testing PC-based software, we can immerse the participants"

[NEXT SLIDE]

Tactical scenario
(USMC Combat Decision Range #32)

Slide # 14

…in a multimedia tactical scenario…"

[PLAY video clip: 14 participant watching screen]

"… the order of march is a HMMWV with a .50 cal, two trucks, and a HMMWV in the rear."

[NEXT SLIDE IMMEDIATELY WHEN VIDEO ENDS]

Two fixed, robotic digital video cameras

Slide # 15

We record everything they do from front and side views…"

[NEXT SLIDE]

Portable and wireless digital video cameras

Slide # 16

"and can record their actions using a handheld device."

[NEXT SLIDE]

Mobile Device Camera demo
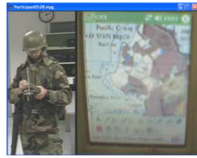
Slide # 17

[switch to live feed from Mobile Device Camera: S-video input on table]

[begin demonstration of actual equipment]

"Up on stage here with me we have a Marine in typical combat dress. I have built battery packs for the equipment so that a researcher can follow a user in the field, recording how they operate the equipment and the context. We are seeing exactly what he does on the screen of his RPDA. All the necessary equipment fits into three waterproof transit cases. An actual field study could validate the results obtained from a controlled laboratory experiment."

[NEXT SLIDE]

[pass out lab manuals]

Noldus Observer software
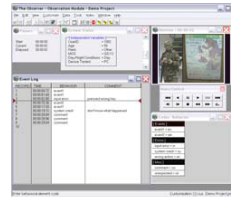
Slide # 18

"We bring all these digital videos back into the Noldus Observer software, where observed behaviors are manually coded into data files."

[NEXT SLIDE]

Video control station hardware

Slide # 19

There are a lot of hardware and software components to the system to install, "

[NEXT SLIDE]

[including a digital video mixer, event coding keyboard, digital camera controller]

Professional recording equipment

Slide # 20

…operate, and maintain. So that this lab will continue to be a valuable resource to the department, "

[NEXT SLIDE]

[Video mix monitors, mic and speaker amps, the wireless camera and microphone receivers, and the computer workstation and its associated software.]

Wiring diagrams
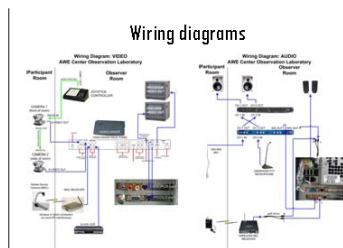
Slide # 21

"…I've written a Users Guide, which distills hundreds of pages of documentation "

[NEXT SLIDE]

Users guide
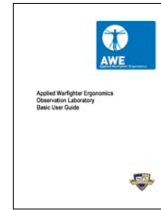
Slide # 22

" and usability references into a focused, stand-alone tutorial."

[NEXT SLIDE]

Approach

Slide # 23

[4:30]

"I also wanted to pave the way for future research by devising and validating…"

[NEXT SLIDE]

Approach for usability testing

1. Definition of need
2. User identification
3. Focus groups & interviews
4. Laboratory and field testing
5. Pre- and post-operation surveys
6. Analysis and final report

Slide # 24

"a start-to-finish methodology for performing a usability study of military individual equipment. I used qualitative and quantitative means to dissect the problem of human factors usability testing."

[NEXT SLIDE]

(My thesis details my experimental design, data collection method, analytical procedure, lessons learned and my recommendations for future researchers.)

Case Study

"To validate this laboratory and procedure, I conducted a small case study comparing three different RPDAs. "

[NEXT SLIDE]

Case Study

Three devices:

RPDA-A   RPDA-B   RPDA-D

"The case study is a proof-of-concept and was not expected to be conclusive. This study is continuing, to achieve the degree of test significance that SOCOM desires"

[NEXT SLIDE]

Participants

Should be representative of intended population

Must be available as test participants

Between-subjects design due to availability of devices and participants (never all at once)

"Soldiers and Marines at DLI brought to NPS in small groups. { A between-subjects experimental design will usually be appropriate because neither the different devices nor the participants will be available for the whole study }"

[NEXT SLIDE]

Pre-operation survey results

64% have a cell phone (5 hr/wk median talk time)

50% have never operated PDA before

54% have a computer at home

median age 20 yrs old

84% directly from boot camp

"The pre-operation survey has 45 questions that attempt to capture the participant's technology experience and their military background."

[5:00]

[NEXT SLIDE]
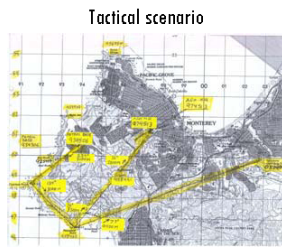
Tactical scenario

Slide # 29

"The participants went through a 30-minute tactical scenario, during which they performed..."

[NEXT SLIDE]

Tactical tasks

1. Perform a communications check
2. Plot a route
3. Determine three map coordinates
4. Determine the bearing and range from one point to another
5. Send a message
6. Receive a message
7. Retrieve a previous message from storage

Slide # 30

"...various communications and navigation tasks. The scenario drove them to perform these tasks using conventional means"

[NEXT SLIDE]

Tactical scenario script

Slide # 31

"...(such as with a paper map), to provide a baseline measure of their abilities. Later, they performed similar tasks using the RPDA."

[Pause, NEXT SLIDE]

Laboratory observations

Slide # 32

[play 33 correct rpda read grid]

"If the quantitative results are not conclusive, we may still be able to make recommendations based on our observations in the lab and the field."

[NEXT SLIDE]

Interface errors

Slide # 33

[play 33 clicking interface error]

"In this segment, it took 23 screen taps to close the dialog box

A great advantage of digital video collection is that you can go back to the original data to interrogate outliers"

[NEXT SLIDE]

Tactical reaction to the scenario, pt. I

Slide # 34

"We saw a broad range of behaviors during the experiment"

[play 35 tactical reaction]

[NEXT SLIDE AS SOON AS VIDEO FINISHES]

Tactical reaction to the scenario, pt. II

Slide # 35

[play 36 nonchalant reaction]

"some of which are correlated to their survey responses"

[NEXT SLIDE]

Conventional mapping, pt. I (Marine)

Slide # 36

[play 37 conv mapping while standing]

"We saw a range of techniques employed. For example, some groups took different tactical postures"

[NEXT SLIDE AS SOON AS VIDEO FINISHES]

Conventional mapping, pt. II (Soldier)

Slide # 37

[play 38 conv mapping spread]

" than others. One group invariably removed their weapons when mapping.

 Some assessments were subjective..."

[NEXT SLIDE AS SOON AS VIDEO FINISHES]

Unresponsive interface

Slide # 38

[play 39 nonresponsive]

"We tried to differentiate between time-consuming tasks, hardware issues, and users misunderstanding the task"

[NEXT SLIDE]

Participant off-task due to confusing instructions
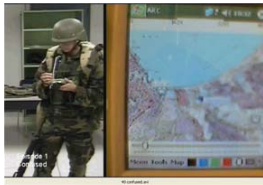
Slide # 39

[play 40 confused]

"For a subjective measurement, how would you know when a tester is confused?"

[MAKE SURE AUDIENCE HEARS HIM SAY, "I'M CONFUSED" – REPLAY IF NECESSARY]

[NEXT SLIDE]

Physical errors due to device configuration
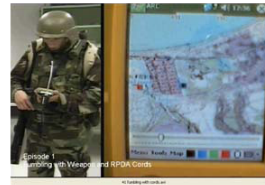
Slide # 40

[play 41 fumbling with cords]

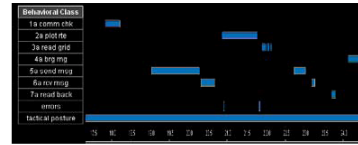"This device is tethered to networking equipment and large batteries in the backpack, which might not be an optimal configuration."

[NEXT SLIDE]

"Researchers code the videos into raw data files like these, that describe every observed event."

[NEXT SLIDE]

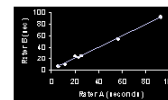"One way to look at that data is through this time-step plot, which shows what the participant was doing throughout the scenario."

[NEXT SLIDE]

"To verify that the measurements are objectively coded, we look at inter-rater reliability."

[NEXT SLIDE]

"We compare the task times assigned by a different researcher on the vertical and horizontal axes and find very good agreement in this observation"

[NEXT SLIDE]

Inter-rater reliability

Confusion matrix

	t1	t2	t3	t4	t5	t6	t7	Error	Total A
t1	22.63	-	-	-	-	-	-	0.33	22.96
t2	-	54.73	-	-	-	-	-	0	54.73
t3	-	-	9.71	-	-	-	-	0	9.71
t4	-	-	-	25.1	-	-	-	0.14	25.24
t5	-	-	-	-	92.06	-	-	0	92.06
t6	-	-	-	-	-	19.53	-	5.8	25.33
t7	-	-	-	-	-	-	5.5	0.94	6.44
Error 0		1.63	1.65	0	0.17	0	0	-	3.45
Tot.B	22.63	56.36	11.36	25.1	92.23	19.53	5.5	7.21	239.92

Duration of agreements:	229.3 sec
Duration of disagreements:	10.66 sec
Index of concordance:	0.96
Cohen's κ:	0.94

Slide # 45

"There are standard statistics we can use to ensure we are using objective measurement criteria."

[NEXT SLIDE]

[The index of concordance is just the proportion of agreements to total observed time.

Cohen's kappa is a measure of the proportion of agreement that exceeds that expected by chance:

K = (observed proportion – proportion expected by chance) / (1 - proportion expected by chance)

Conclusions

Slide # 46

"There are a few key points I considered in my case study, and propose for future studies"

[NEXT SLIDE]

Analytical method

Adjust measurements for participant effects

Analyze task times for a device effect

Use parametric techniques for a richer model

Use non-parametric techniques for insurance against poor assumptions and small data sets

Slide # 47

"Quantifying individual differences between participants reduces the noise in the measurements, and reduces our required sample size.

With a properly constructed experiment, we can justify quantitative analysis of human factors data."

[NEXT SLIDE]

Participant effect

Between-participant variability is greater than between-device variability

Finding factors that explain participant variability:
Pre-operation surveys
Conventional tasks to establish baselines

Slide # 48

"Testable measures of participant effect, like the baseline tasks, are preferable to surveys, which are prone to a variety of errors."

[NEXT SLIDE]

Slide # 49

Parametric analysis

ANOVA model:

```
> t5.aov=aov(t5~dev,data=rpda)
> anova(t5.aov)
Analysis of Variance Table
         Df Sum of Sq Mean Sq F Value  Pr(F)
    dev  2     16999    8499    5.57   0.0357
Residuals 7    10689    1527
```

Slide # 49

"Here's a simple example of analyzing this data. In task 5, we see a difference between devices,"

[NEXT SLIDE]

Slide # 50

Parametric analysis

ANOVA model:

```
> multicomp(t5.aov)
95 % simultaneous confidence intervals for specified
linear combinations, by the Tukey method
      Estimate Std.Error Lower Bound Upper Bound
A-B     98.6     35.7       -6.47      204.0
A-D     85.6     28.5        1.59      170.0 ****
B-D    -13.0     32.7     -109.00       83.3
```

Slide # 50

"and conclude that using RDA-D is in fact faster than RPDA-A. We also see that device B is better than A at a slightly lower confidence level."

[NEXT SLIDE]

Slide # 51

Non-parametric analysis

Kruskal-wallis test

```
> kruskal.test(t5, dev)
Kruskal-Wallis chi-square = 6.0695, df = 2,
p-value = 0.0481
```

Kruskal-wallis multi-comparison results (α = 0.05):
B is better than A, and D is better than A (same as ANOVA)

(S-Plus code for multi-comparisons omitted)

Slide # 51

"We arrive at the same conclusions non-parametrically. However, when adjusting for participant effects, we did not find a statistically significant difference between the devices in this study."

[NEXT SLIDE]

Slide # 52

Subjective analysis

Highlight video clips

Post-operation survey results

Subject matter expert review

Slide # 52

"On the other hand, some users did voice strong opinions about the devices in their post-operation surveys. My research has shown that perception can influence the adoption of innovations more strongly than quantitative performance.

[NEXT SLIDE]

AWE
Applied Warfighter Ergonomics

Slide # 53

"My thesis fills the human factors gap in the T&E process. There are Special Forces operators and Marines in Iraq and Afghanistan using all of these devices today. My thesis results will be applied by SOCOM to improving current and future RPDAs. This laboratory will make the Naval Postgraduate School the premiere military individual equipment testing site in the country."

[BE PREPARED TO SWITCH TO THESIS IN WORD]

"The bulk of my thesis effort was in designing and testing the laboratory and structure, and I'd be happy to go into more details about it. I can also

---

Great things about my thesis experience

Created a research question exactly in line with my professional and academic interests.

Faced few constraints in devising my research plan.

Was actively involved in collecting my own data.

Had complete freedom in designing and establishing a laboratory specifically for my research.

Slide # 54

"Some great things about my thesis experience are that I was able to pursue a research question exactly in line with my professional and academic interests, I faced few constraints in devising my research plan, I was actively involved in collecting my own data, and I had complete freedom in designing and establishing a laboratory specifically for my research. A few of the drawbacks were that I… "

[NEXT SLIDE]

Drawbacks of my thesis experience

Had to come up with my own research questions.

Had to come up with my own plan.

Had to get my own data.

Had to build my own lab…

Slide # 55

"…had to come up with my own research questions, my own research plan, I had to get my own data, and I had to build my own lab…"

[NEXT SLIDE]

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